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EFFECT OF AEROATION UPON A SMALL MARINA

Norman R. Sedlander

Toledo University

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by

Norman R. Sedlander

Professor

Civil Engineering Department

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1966

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The University of Toledo expresses its appreciation to the United States Public Health Service for its support in the past and the time allowed for completion of the final report.

Much credit should be given to those students, secretaries, and to my wife for having given so generously of their time and effort. It would have been more than an arduous task to complete all facets of this project without their cooperation.

INTRODUCTION

Basically the study was divided into two parts. The procedure was to compare the results of an unaerated period, 1964, with the aeration of the basin in 1965.

As with all research, certain factors arose which were not anticipated at its inception. Because of the many variables observed, such as wind, rainfall, etc., a joint laboratory study was conducted at the same time. Those findings observed in the marina basin were confirmed by similar characteristics found in the laboratory study.

At the same time studies of a more basic nature were conducted in the laboratory to verify other assumptions made during the term of the project. Most assumptions were verified. Low pressure aeration of stagnant estuaries proved to be efficacious.

FOREWORD

In 1962 the DeVilbiss Company of Toledo approached the University of Toledo with the problem of determining the best hole spacing in plastic hose for the purpose of preventing freezing around the piling in marinas during winter months. In the past, boat docks in the Toledo area have been observed to rise as much as thirty degrees from the horizontal due to the lifting action of ice during freeze and thaw periods in winter.

It was found that plastic hose around the docks needed approximately a three foot hole spacing to provide the necessary flow of warmer bottom water to the surface and thus prevent freezing. This experiment was performed for the Bay View and Toledo Yacht Clubs only. Average depth was approximately six to eight feet in the channels.

At the time of the freeze-thaw experiments, the suggestion was made that aeration in the summer months might aid in reducing the insanitary conditions of the marina during the yachting season.

The Shellfish Division of USPHS supported a limited study for the summer of 1963 from which some of the indications observed on the present experiment were apparent. It was found that at the beginning of the summer a supersaturated dissolved oxygen content appeared in the marina. In early July, 1963, compressors were turned on and the oxygen level was reduced nearer to that of saturation for the prevailing summer temperatures. Thus, as always has been known, algae produce oxygen in excess in an attempt to clarify a stagnant body of water. The water seemed clearer and boat owners reported that lower hulls were easier to clean than in past years. The number of fish in the lagoon increased. It was concluded that the additional air did tend to restore a somewhat better biological balance which had not been evident for many years prior to the summer of 1963.

It can not be said that low pressure aeration will solve insanitary conditions of a marina in a short period of time, but that constant application over the years would eventually improve the biological balance to a degree far better than it is at this time.

SECTION I

LABORATORY STUDIES

Review of Data and Observations

1964 - 1965

LABORATORY PROCEDURE

All procedures used were in accordance with criteria as set forth in STANDARD METHODS. The analyses which were run in 1964 and 1965 are recorded in Report No. 1, EF-0052-01 and Report No. 3, EF-0052-02.

The data and graphs recorded in this report are as follows:

1. Dissolved Oxygen
2. Carbon Dioxide
3. Biochemical Oxygen Demand
4. Hydrogen Ion Concentration
5. Turbidity
6. Nitrates
7. Phosphates
8. Temperature

KEY

TANKS NO. 1 AND NO. 2*

DO - 1, 2	Dissolved Oxygen	MG/L
CO_2 - 1, 2	Carbon Dioxide	MG/L
BOD - 1, 2	Biochemical Oxygen Demand	MG/L
PH - 1, 2	Hydrogen Ion Concentration	MG/L
Turb - 1, 2	Turbidity	Turbidity Units
NO_3 - 1, 2	Nitrate Concentration	MG/L
PO_4 - 1, 2	Phosphate Concentration	MG/L
°C - 1, 2	Temperature, Centigrade	°C

* NOTE: No. 1 Tank - Unaerated

No. 2 Tank - Aerated

TABLE I

DATA FOR TANKS NO. 1 AND NO. 2

TYPE ANALYSIS - See Key, Page

MONTH - June-July-August 1964

Date	DO-1	DO-2	CO_2-1	CO_2-2	PH-1	PH-2	Turb-1	Turb-2
6-24	4.7	5.0	----	----	---	---	--	--
6026	5.0	7.9	10.0	10.0	7.5	7.9	22	22
6-29	4.7	7.5	10.0	5.0	7.7	8.1	16	20
7-1	5.0	7.6	5.0	5.0	7.9	8.0	21	20
7-3	5.6	7.5	5.0	5.0	7.7	7.9	16	8
7-6	6.2	7.3	10.0	5.0	7.6	7.9	8	8
7-8	6.0	7.0	-----	----	7.9	7.9	18	14
7-10	6.7	6.8	10.1	10.7	7.95	8.0	14	8
7-13	6.6	7.7	25.0	25.0	8.0	8.1	12	4
7-15	6.4	7.3	15.2	7.1	8.4	7.3	12	8
7-17	6.8	7.6	10.1	8.1	8.0	8.0	86	16
7-20	6.0	7.2	5.1	5.1	7.7	8.0	4	4
7-22	6.8	7.6	10.1	7.1	8.0	8.1	20	4
7-24	6.3	6.8	7.1	5.1	7.9	8.1	12	8
7-27	6.5	6.8	5.1	4.0	8.1	8.1	30	39
7-29	6.2	6.8	5.1	15.2	8.1	8.6	49	56
7-31	6.5	7.4	10.12	7.1	8.0	8.0	12	4
8-3	7.2	7.5	40.5	7.9	8.0	8.1	61	73
8-5	7.8	6.9	3.0	5.1	8.1	8.1	32	47
8-7	7.6	7.3	2.0	2.0	8.3	8.3	16	22

TABLE I (continued)

DATA FOR TANKS NO. 1 AND NO. 2

TYPE ANALYSIS - See Key,

MONTH - August
1964

Date	DO-1	DO-2	CO_2-1	CO_2-2	PH-1	PH-2	Turb-1	Turb-2
8-10	7.9	7.5	4.1	4.1	8.3	8.2	4	8
8-12	7.8	7.5	Tr	Tr	8.4	8.4	8	4
8-14	7.5	7.5	Tr	Tr	8.3	8.3	8	8
8-17	7.6	8.0	5.0	Tr	8.2	8.3	16	12
8-19	8.6	8.2	Tr	7.2	8.4	8.4	4	8
8-21	8.1	7.7	1.0	Tr	8.3	8.3	12	4
8-24	8.0	8.3	5.1	4.1	8.1	8.1	8	20
8-26	8.5	8.3	Tr	5.1	8.3	8.3	4	12
8-28	3.0	2.8	Tr	Tr	8.3	8.3	16	16

TABLE II

DATA FOR TANKS NO. 1 AND NO. 2

TYPE ANALYSIS - See Key,

MONTH - June-July
1964

Date	NO_3-1	NO_3-2	PO_4-1	PO_4-2	°C-1	°C-2
6-24	---	---	----	----	27.0	27.0
6-26	---	---	2.76	2.87	26.0	26.0
6-29	1.3	0.7	2.66	1.20	25.5	25.5
7-1	Tr	1.15	2.27	2.02	27.0	27.0
7-3	0.5	0.9	1.97	1.50	26.0	26.0
7-6	0.2	0.5	1.41	0.90	25.5	25.5
7-8	0.8	1.0	----	----	25.0	25.0
7-10	---	---	----	----	26.5	26.5
7-13	2.2	1.3	1.41	1.41	25.0	25.0
7-15	0.3	0.3	0.90	0.71	24.0	24.0
7-17	0.6	0.5	1.34	2.41	26.0	26.0
7-20	1.0	1.1	1.30	0.63	28.0	28.0
7-22	0.3	1.4	0.98	0.46	28.0	28.0
7-24	0.3	0.55	0.30	0.55	29.0	29.0
7-27	1.3	1.5	----	----	29.5	29.5
7-29	2.3	2.6	0.40	0.21	28.0	28.0
7-31	1.1	0.1	0.55	0.55	----	----

TABLE II (continued)

DATA FOR TANKS NO. 1 AND NO. 2

TYPE ANALYSIS - See Key,

MONTH - August
1964

Date	NO_3-1	NO_3-2	PO_4-1	PO_4-2	°C-1	°C-2
8-3	0.4	1.1	0.11	0.07	28.0	28.0
8-5	1.2	1.2	0.55	0.55	26.5	26.5
8-7	1.6	1.2	0.19	0.12	26.5	26.5
8-10	1.1	1.2	0.36	0.19	24.0	24.0
8-12	0.5	1.0	0.30	0.21	24.0	24.0
8-14	0.6	1.4	1.34	0.44	----	----
8-17	0.8	0.6	0.38	0.19	24.5	24.5
8-19	0.1	1.3	0.33	0.34	24.0	24.0
8-21	1.3	1.2	0.16	0.19	23.0	23.0
8-24	2.7	3.5	0.04	0.34	24.0	24.0
8-26	1.4	1.4	0.32	0.32	24.0	24.0
8-28	1.2	1.5	0.02	0.04	24.0	24.0

TABLE III

DATA FOR TANK NO. 1 AND NO. 2

TYPE ANALYSIS - See Key.

MONTH - June-July-August
1965

Date	DO-1	DO-2	CO_2-1	CO_2-2	BOD-1	BOD-2	PH-1	PH-2	Turb-1	Turb-2
6-15	7.5	8.0	Tr	Tr	1.0	1.0	8.9	9.1	30	32
6-17	8.8	9.0	Tr	Tr	---	----	8.9	9.0	30	32
6-22	7.5	7.2	Tr	Tr	4.67	4.67	8.8	8.8	16	26
6-24	7.6	6.7	Tr	Tr	3.80	5.70	9.0	9.0	12	22
6-29	7.3	7.5	Tr	Tr	1.22	1.84	8.9	9.0	8	36
7-1	7.5	8.0	Tr	Tr	1.08	5.15	9.1	9.3	20	49
7-8	8.0	7.5	Tr	Tr	2.80	7.30	9.2	9.2	8	36
7-13	4.9	7.3	Tr	Tr	----	1.8	8.5	8.6	12	22
7-15	5.9	7.5	Tr	Tr	----	----	8.6	8.85	20	26
7-20	8.5	7.4	Tr	Tr	1.0	1.0	8.9	8.75	20	12
7-22	9.2	7.8	Tr	Tr	2.97	1.08	8.8	8.7	22	22
7-27	8.7	8.2	Tr	Tr	2.16	1.62	8.9	8.8	12	12
7-29	8.5	8.2	Tr	Tr	3.25	4.30	8.85	8.9	12	4
8-3	9.0	9.0	Tr	Tr	2.97	17.60	9.0	9.2	20	26
8-10	9.0	8.5	Tr	Tr	4.34	16.8	8.8	9.0	20	39
8-12	9.8	8.4	Tr	Tr	1.0	2.43	8.9	9.1	20	36
8-17	9.0	7.3	Tr	Tr	4.3	15.0	9.0	8.9	4	12
8-19	6.7	6.0	Tr	Tr	3.9	4.2	9.1	8.85	12	22
8-24	8.7	9.2	Tr	Tr	----	5.4	8.85	8.9	16	30
8-26	7.4	7.0	Tr	Tr	5.3	4.6	8.85	8.95	20	12

TABLE IV

DATA FOR TANKS NO. 1 AND NO. 2

TYPE ANALYSIS - See Key,

MONTH - June-July-August
1965

Date	NO_3-1	NO_3-2	PO_4-1	PO_4-2	°C-1	°C-2
6-15	0.5	0.6	0.25	0.32	25	25
6-17	0.6	0.3	0.36	0.25	24	24
6-22	0.4	0.2	0.40	0.34	27	27
6-24	0.4	0.1	0.50	0.26	26	26
6-29	0.3	0.2	0.48	0.42	25	24
7-1	0.3	0.4	0.30	0.04	26.5	26.5
7-8	0.3	0.6	0.11	0.11	25.5	25.5
7-13	0.2	0.6	0.30	0.32	26.4	26.4
7-15	0.5	0.6	0.28	0.26	25.5	25.5
7-20	0.6	0.8	0.28	0.44	24.5	24.5
7-22	0.3	0.6	0.38	0.25	28	28
7-27	0.4	0.7	0.34	0.34	28	28
7-29	0.7	0.6	----	----	25	26
8-3	1.0	0.7	0.36	0.07	23	24
8-10	0.5	0.6	0.11	0.11	26	26
8-12	0.7	0.4	0.38	0.16	25	25
8-17	1.2	0.3	0.07	0.01	29.5	29.5
8-19'	0.5	0.5	0.11	0.01	28	28
8-24	0.5	0.3	0.11	0.07	25.5	25.5
8-26	0.8	0.7	0.04	0.01	25	25

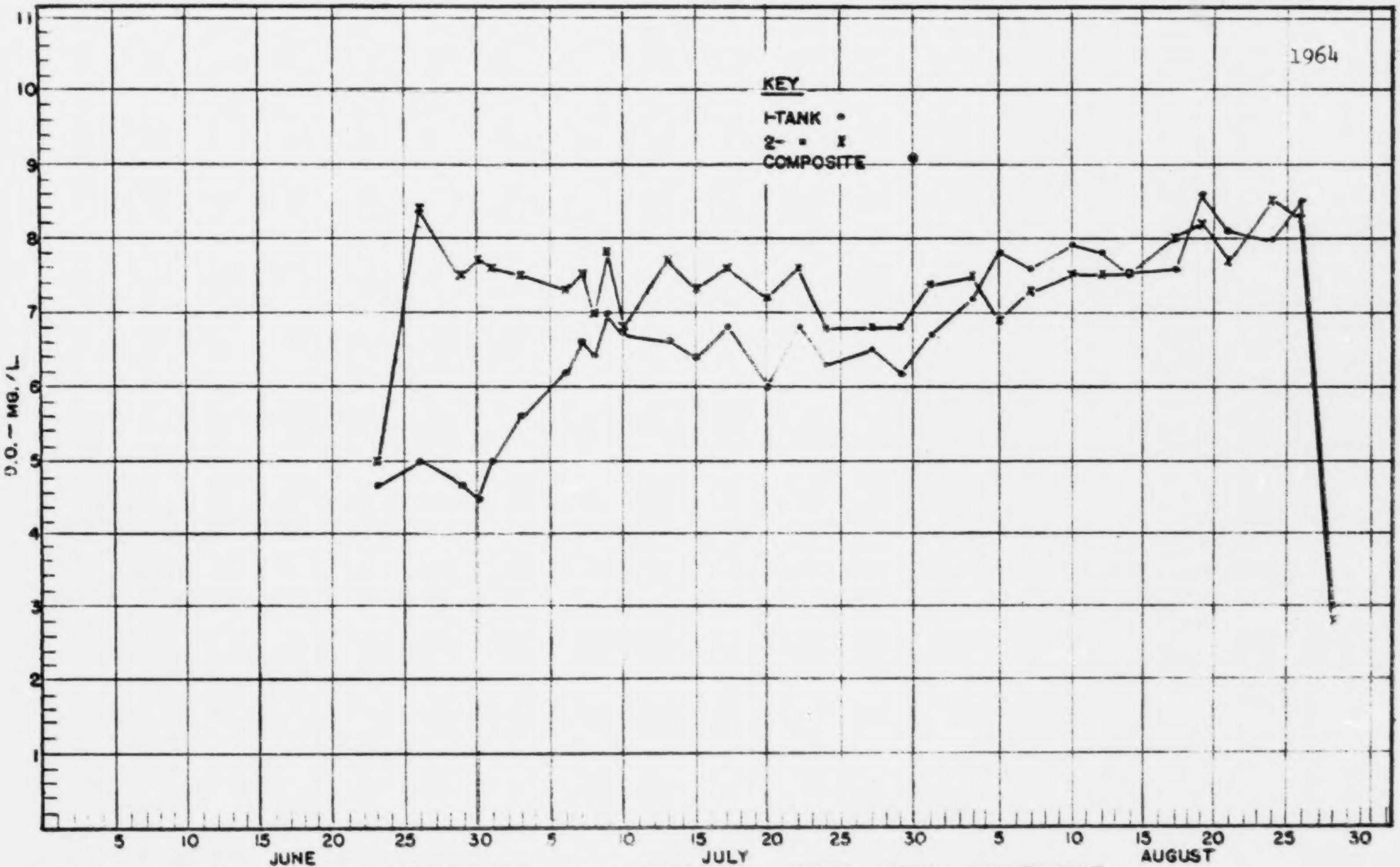


FIG. 1 DISSOLVED OXYGEN CONCENTRATION IN LABORATORY WATER BATH EXPERIMENT

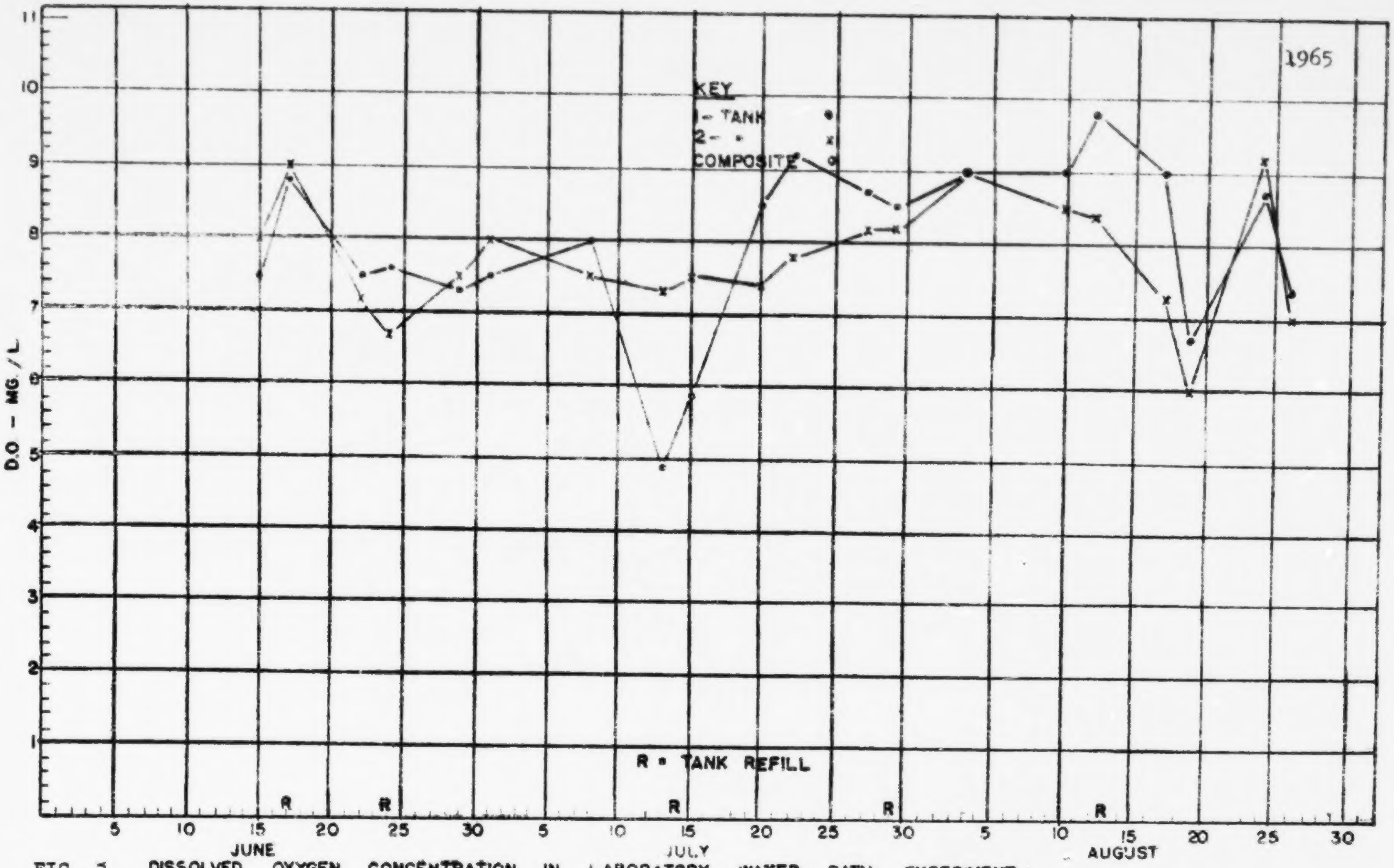


FIG. 2 DISSOLVED OXYGEN CONCENTRATION IN LABORATORY WATER BATH EXPERIMENT

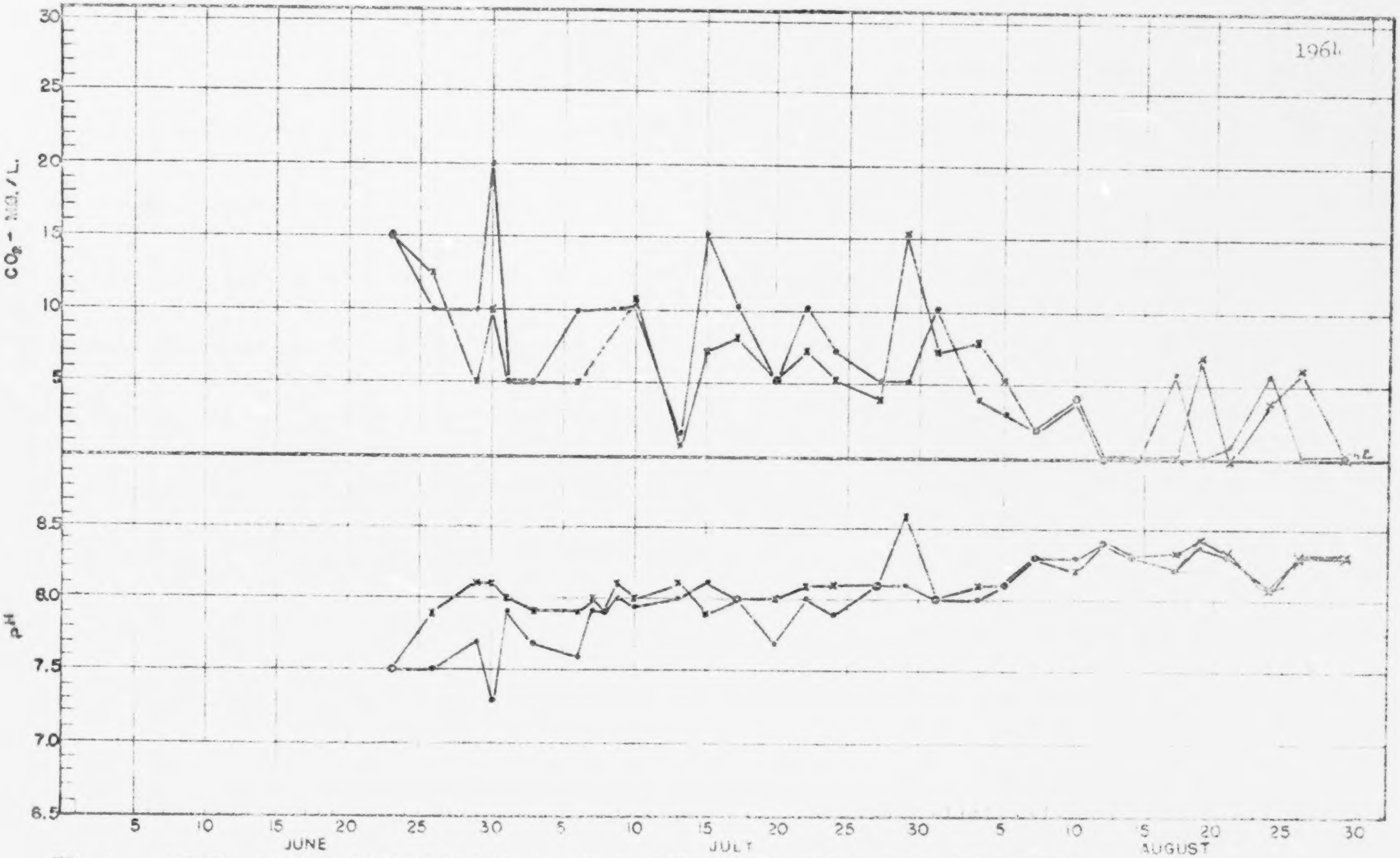


FIG.3 CARBON DIOXIDE CONCENTRATION & pH IN LABORATORY WATER BATH EXPERIMENT

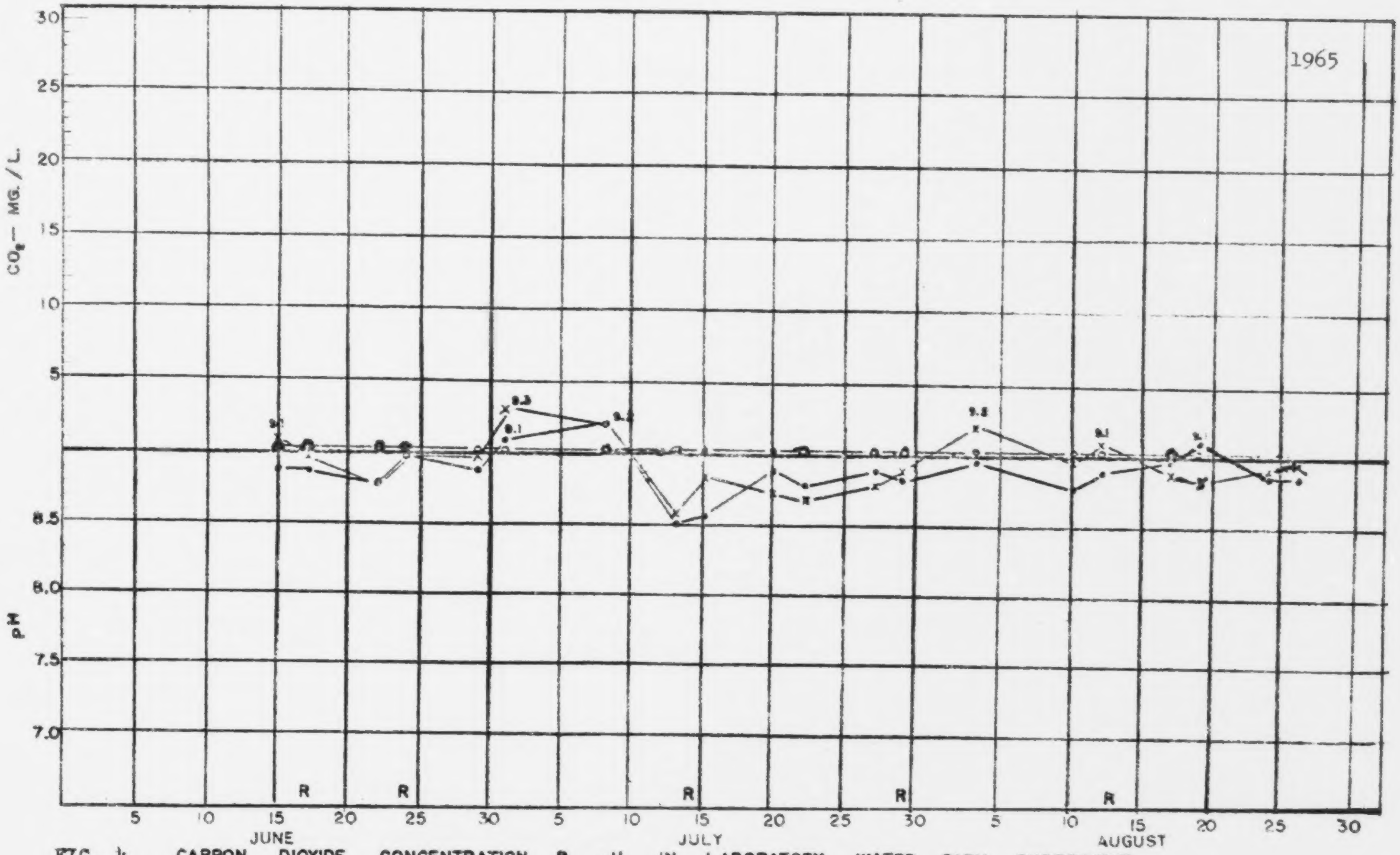


FIG. 4 CARBON DIOXIDE CONCENTRATION & pH IN LABORATORY WATER BATH EXPERIMENT

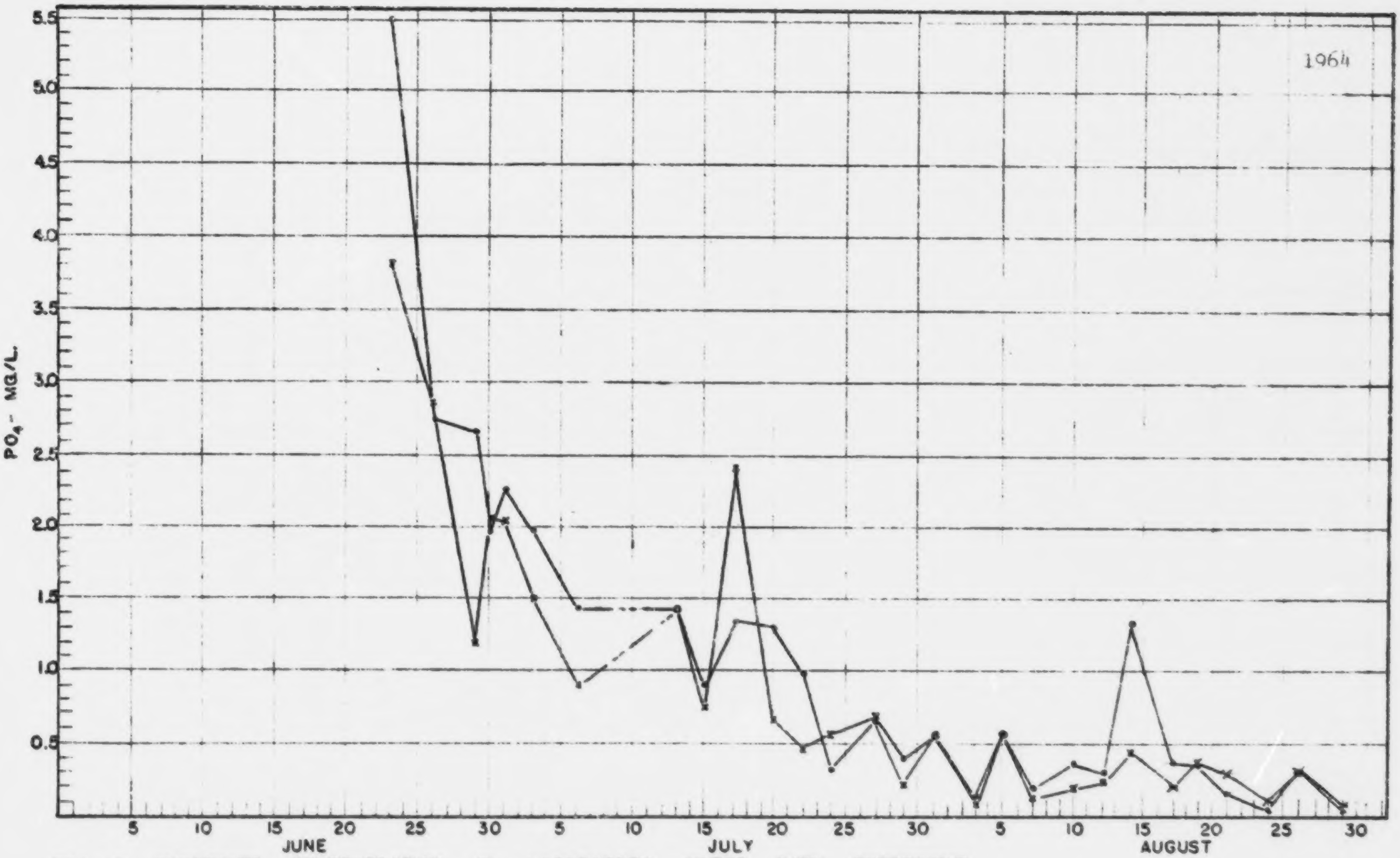


FIG. 5 PHOSPHATE CONCENTRATION IN LABORATORY WATER BATH EXPERIMENT

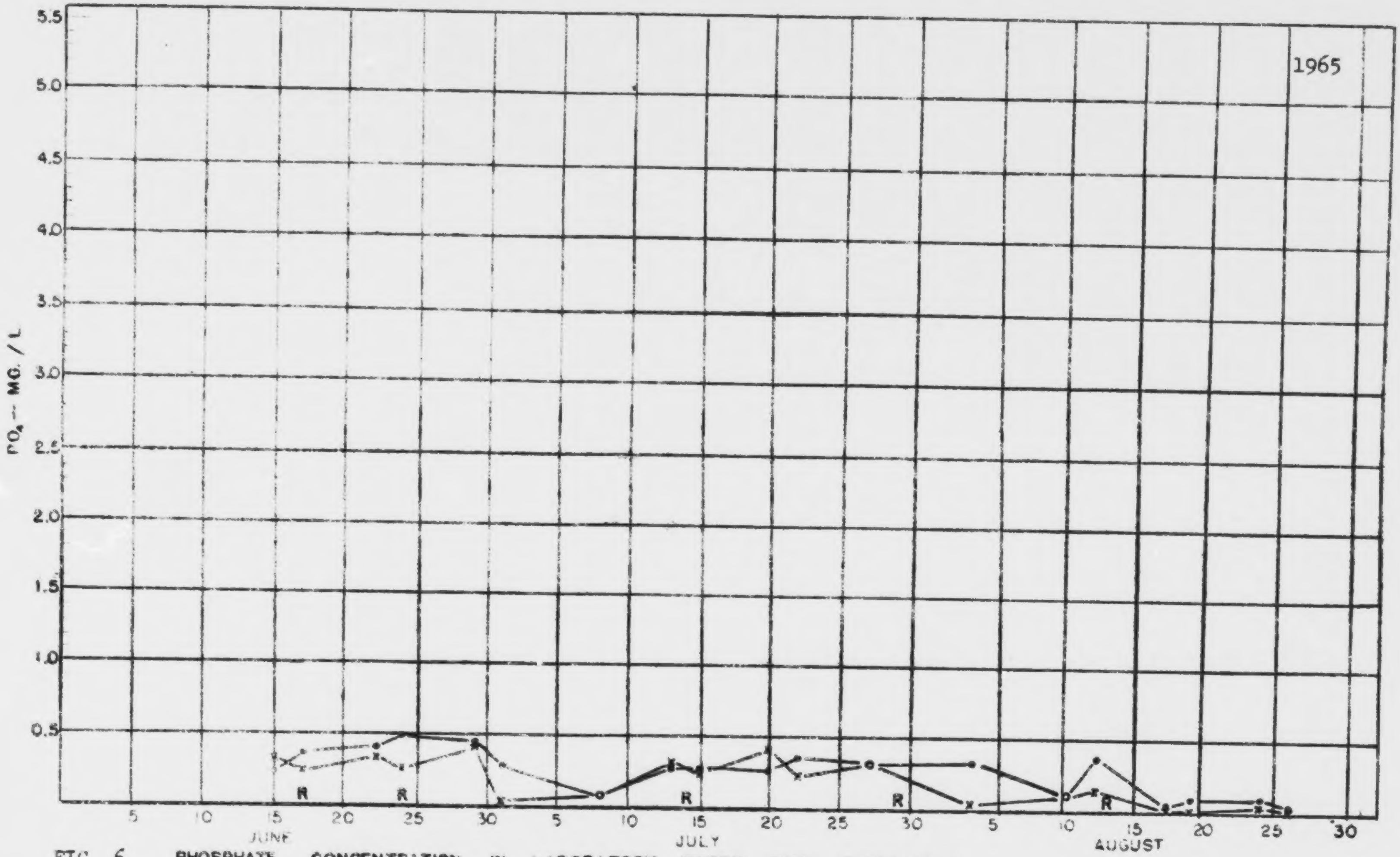


FIG. 6 PHOSPHATE CONCENTRATION IN LABORATORY WATER BATH EXPERIMENT

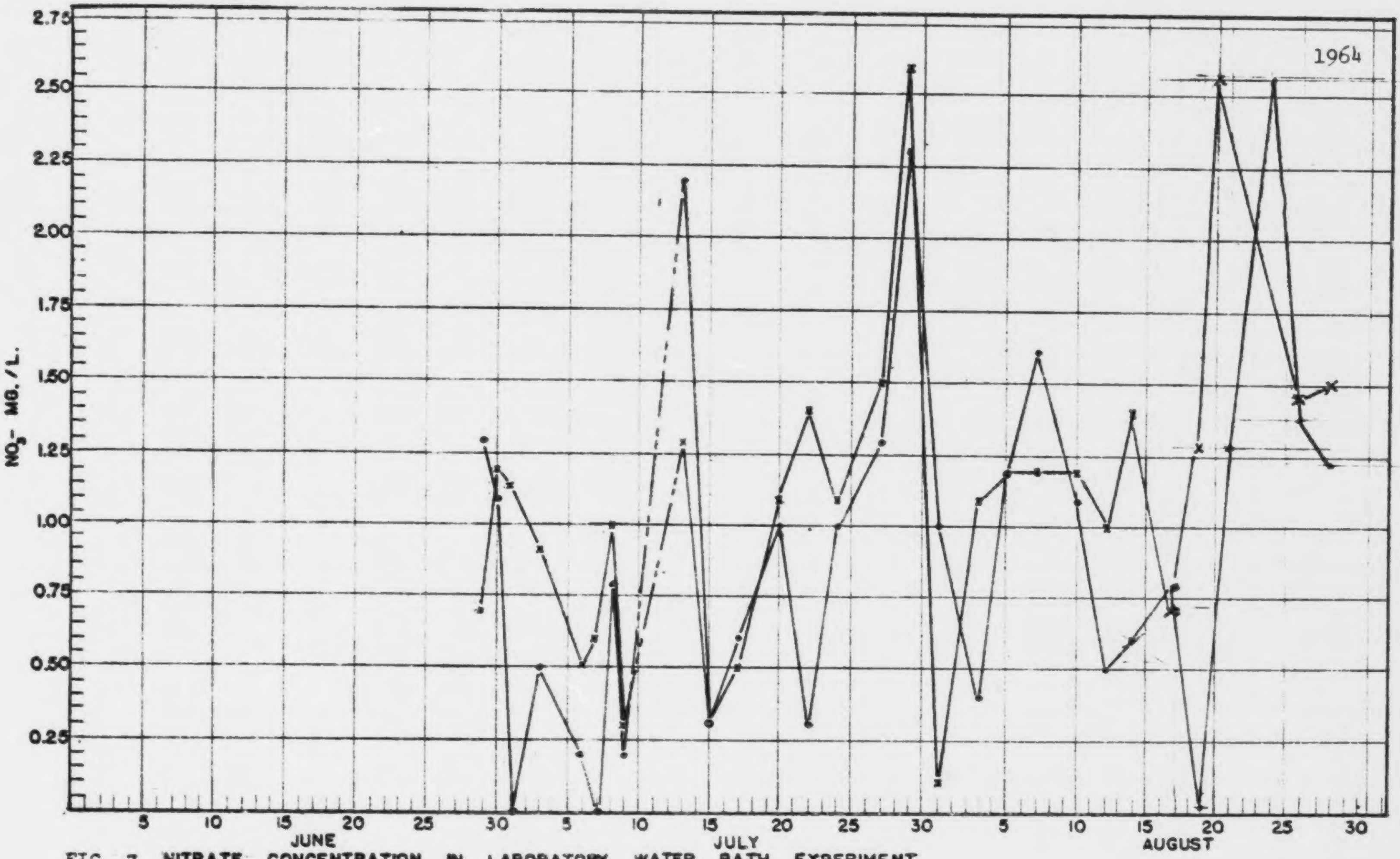


FIG. 7 NITRATE CONCENTRATION IN LABORATORY WATER BATH EXPERIMENT

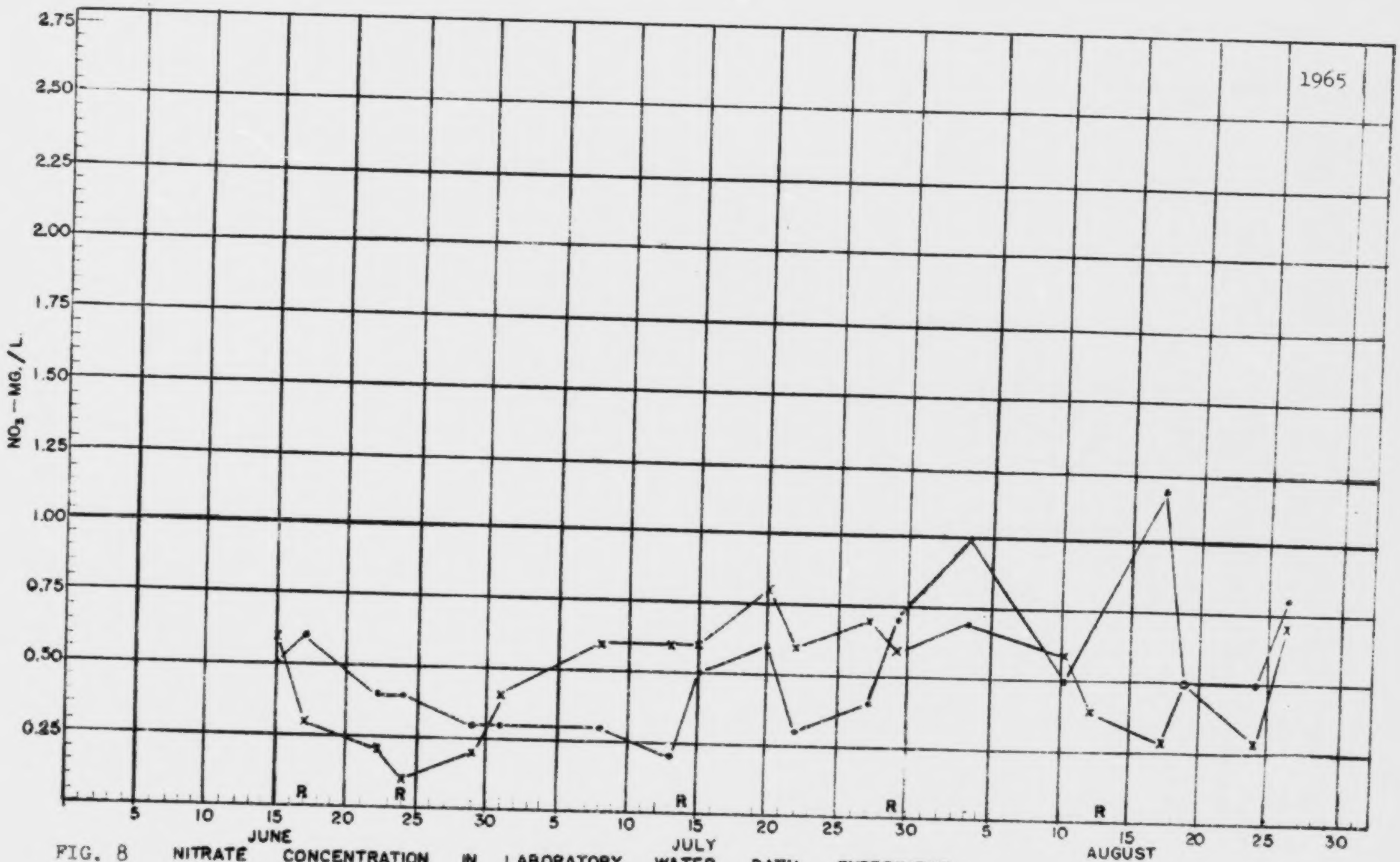


FIG. 8 NITRATE CONCENTRATION IN LABORATORY WATER BATH EXPERIMENT

DISCUSSION

Because of the wide variation in environmental factors observed at the marina, a parallel laboratory study was begun during the summer of 1964 and continued on a limited basis throughout the term of the project to provide a more controlled environment.

Initially it was thought that continuous room lighting would provide sufficient light for photosynthesis, but after a period of observation not a great deal of activity was noted. Flood lights were installed, and, in a relatively short time aquatic growth (algae) appeared on the surface and grew at a rapid rate in the unaerated tank. In the aerated tank, algae grew rapidly but then disappeared in approximately one week.

Every two weeks, the water in the tanks was replenished to make up for water lost in evaporation. The average amount required was fifty gallons. After replensihment, the water became turbid in both tanks. During the winter months, it was possible to produce a clear, sparkling water in the aerated tank in less than a week. In the unaerated tank, sedimentation did occur, but the surface was covered with dust, oils, and aquatic growth.

After the first spring thaw, the water remained turbid for nearly two weeks before clear water appeared in the aerated tank. As summer approached, the length of time for clarification increased beyond two weeks. This increased clarification time was due to the large amounts of silt in the refill water. Thereafter, water was obtained above a dam about one half mile upstream. Above the dam, transport velocity was not sufficient to keep sediment in suspension. The refill water contained a greater amount of algae, and clarification time in the aerated tank was reduced. Aquatic growth also increased at a greater rate under the flood lights of the unaerated tank.

It was noted that the algae in the aerated tank were kept in suspension by the movement of the rising air bubbles which produced a better environment for the reduction of nutrients. Observations of increased turbidity in the aerated tank indicated a higher algal growth rate in the aerated tank than in the unaerated tank. During this nutrient stripping period, the water in the aerated tank took on an intense blue-green color while the surface of the unaerated tank was always covered with a layer of scum. Although all the necessary requirements for increased algal growth rates were provided, i.e., carbon dioxide in the compressed air, nutrients present in the water, adequate lighting for photosynthesis, and mixing by bubbling, the mechanism of clarification was not clearly understood. Further study is needed to clarify this phenomenon.

Study of the literature has shown that algae do have a mucous sheath surrounding the cell. Certain types of algae have a negative surface charge. Studies were carried out in the laboratory for verification of the charge surrounding the cell in the particular study.

A modified electrophoresus experiment was set up and observation revealed that while the migration velocity was very slow, there was a definite attraction towards the positive pole. This experiment confirmed that algae in this system were surrounded by a very slight negative charge.

According to J. Verduin(1), algae will produce oxygen when provided with a proper environment and require oxygen during periods of darkness. A five gallon sample of water was taken from the aerated tank during a period of high algal growth rate. Measurements of the oxygen production and depletion were measured both chemically (Winkler) and by a strip chart rec order. The use of the two methods provided a confirmation of measurements over a continuous period of time. The results of this experiment proved that in this particular system, production and depletion of oxygen were similar to the work done by Verduin.

In an unaerated system, observations of projects by N. R. Sedlander, Jr.(2) and James Haube(3) revealed there is a tendency for agglomeration of algal cells after a certain period of time. It was noted in an unaerated system that clumps of algae were lifted from the bottom of the surface of the water by an attached bubble. Release of the bubble at the surface caused the algae to sink. Haube did note that in an aerated system the collision of cells tended to cause agglomeration. In another experiment, after a period of high algal growth, glutamic acid and glucose were added to both an aerated and unaerated system. There was an immediate drop in dissolved oxygen in both tanks. Within three days, the aerated system had recovered and the unaerated system became anerobic. Hydrogen sulfide and other gases were released and reached a point where the unaerated tank had to be placed under a ventilation hood. There was no oxygen recovery in the unaerated system which indicated the effectiveness of diffused air in maintaining a proper environment.

It was also found that in an aerated system, dissolved oxygen remained near the saturation level and that supersaturation occurred in an unaerated tank. It was also found that dissolved oxygen content remained more stable in the aerated tank. In the presence of algae, carbon dioxide levels were negligible.

According to A. J. McDonnel, et. al.(4), biochemical oxygen demand tends to follow the amount of dissolved oxygen present. At no time was the demand exceedingly high. This same trend has been evident in previous studies performed in Toledo.

Since this was a controlled environment, the temperature changes in the water were not comparable to those in the marina. Partial elimination of this variable aided observations of algal growth patterns.

Phosphate concentration beginning in the summer of 1964 through the study period of the summer of 1965 dropped perceptibly through the year.

Once the phosphates were reduced to a minimum, at no time did the concentration rise to its initial level, indicating utilization of phosphates by algae. (See Figures 5 and 6)

At the beginning of the water bath study, nitrate concentrations varied widely. As the study progressed, nitrate concentrations decreased and did not fluctuate as was the case in the beginning. (See Figures 7 and 8)

The hydrogen ion concentration remained constantly about pH 7 at all times. Generally, the level averaged nearer pH 8. At the observed measurements made during the two years, optimum algal growth rates occurred in the approximate area of pH 8 and above.

Turbidity measurements were made periodically. These readings are not considered to be valid because of the suspension of algae in the aerated tank. It did serve as an indicator of the algae concentration in the aerated tank.

A second laboratory study was initiated to study such factors as cell weight, growth rate (K), equivalent oxygen production, and temperatures for an unaerated and aerated closed batch-type system.

It was found that more favorable conditions existed in the aerated suspension for growth and multiplication. The logarithmic portion of growth curves were found to be 50-hours for the unaerated suspension and 223-hours for the aerated. This is an increase of 3 times in the length of time during which cells are most actively dividing.

Cell population showed an increase of 219 times the initial population as compared to an increase of 5.1 times in the aerated suspension. This finding supports the assumption that growth of the unaerated cells was limited by carbon dioxide and not light intensity or nutrients. The aerated suspension reached a stationary state only when the turbidity became so great as to exclude penetration of adequate light for growth and photosynthesis. (See Report No. 2)

Comparison of dissolved oxygen content shows higher levels were consistantly observed in the unaerated suspension although the average estimated oxygen production by the aerated cells was 49.0% greater. These higher levels are thought to be due to the presence of accumulated recent oxygen from the algal photosynthesis. This was not observed in the aerated suspension since turbulence from the gas sparger forced bubbles out of the suspension before they could accumulate.

Observation of growth rates in terms of cell weight show that cell weight and oxygen produced reached a peak prior to the time the growth curve reached its maximum in the unaerated system. Observation of the growth rate and cell dry weight in the aerated system reached a maximum cell weight and growth weight approximately at the same time.

SECTION II

[illegible]

Review of Data and Observations

1964 - 1965

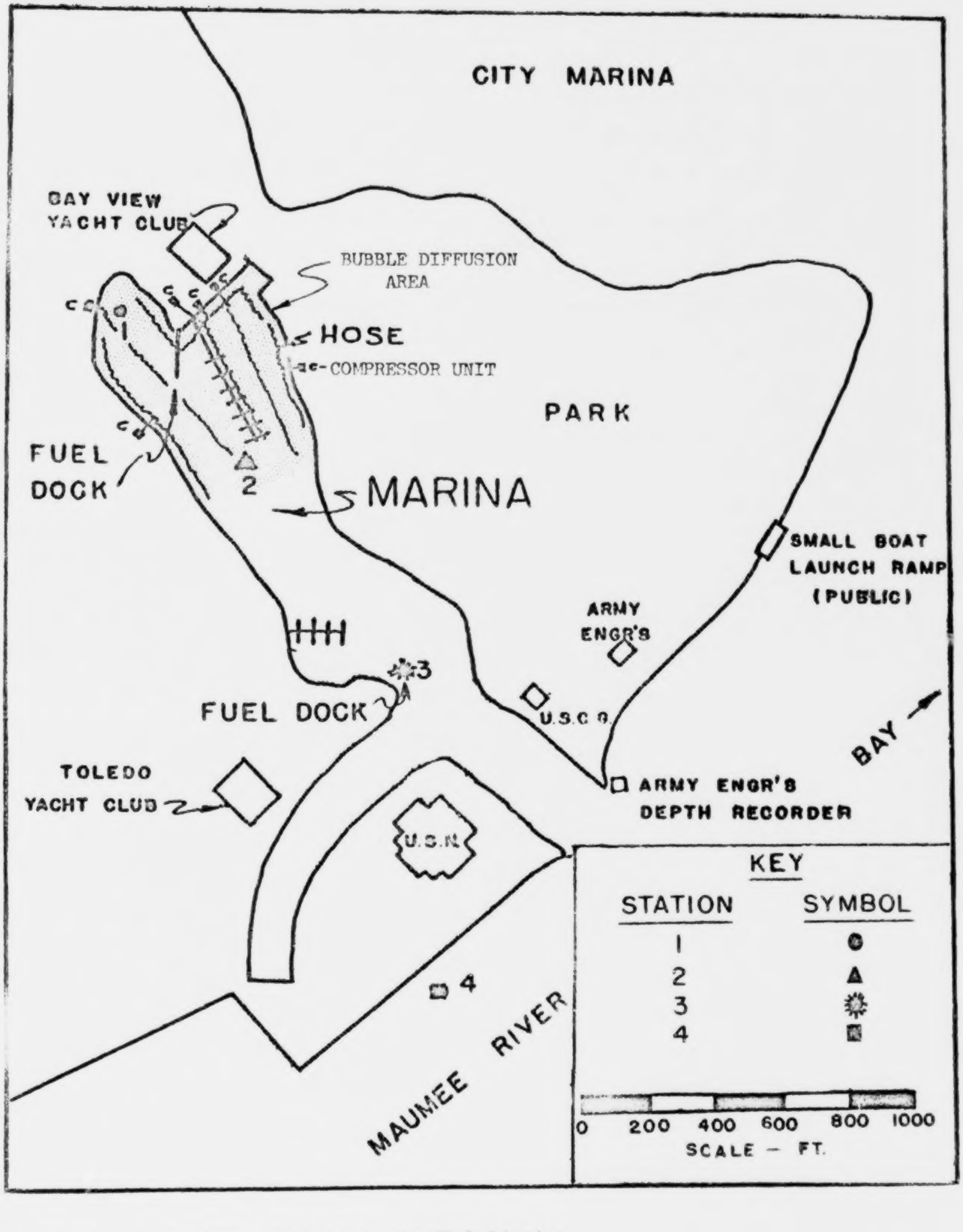

CITY MARINA
BAY VIEW YACHT CLUB
BUBBLE DIFFUSION AREA
HOSE
COMPRESSOR UNIT
PARK
1
FUEL DOCK
2
MARINA
SMALL BOAT LAUNCH RAMP (PUBLIC)
ARMY ENGR'S
3
FUEL DOCK
U.S.C.G.
BAY
TOLEDO YACHT CLUB
U.S.N.
ARMY ENGR'S DEPTH RECORDER
4
MAUMEE RIVER
KEY
STATION SYMBOL
1 ●
2 ▲
3 ✹
4 ■
0 200 400 600 800 1000
SCALE – FT.

Figure 1. Bay View - Toledo Yacht Club Marina

MARINA PROCEDURE

Sanitary and microbiological analysis of marina samples were performed in accordance with criteria as set forth in STANDARD METHODS. All data for 1964 and 1965 are recorded in Report No. 1, EF 0052-01 and Report No. 3, EF 0052-02.

The data and graphs recorded in this report are as follows:

1. Dissolved Oxygen
2. Carbon Dioxide
3. Hydrogen Ion Concentration
4. Biochemical Oxygen Demand
5. Phosphates
6. Nitrates
7. Viable Bacteria
8. Coliform Organisms
9. Phytoplankton
10. Enterococci
11. Average Numbers (1965) of Bacterial Samples
12. Turbidity Units
13. Water Level
14. Water Temperature
15. Climatology

TABLE I

TYPE ANALYSIS: Dissolved Oxygen MONTH: June-July 1964

Date	Marina Station			
	1	2	3	4
6-8	10.0	8.0	3.5	3.4
6-10	9.3	6.9	5.4	4.0
6-12	9.0	7.6	6.5	4.7
6-15	9.3	8.2	7.1	5.0
6-17	8.3	8.2	4.9	4.4
6-19	10.5	10.5	7.2	5.8
6-22	5.8	4.0	2.9	3.5
6-24	7.8	7.7	5.6	5.4
6-26	12.3	11.6	6.0	4.9
6-29	11.5	7.8	5.3	2.1
7-1	3.8	3.5	2.0	1.8
7-3	3.8	3.0	2.0	0.6
7-6	12.7	9.2	5.2	1.5
7-8	12.7	8.2	3.0	2.0
7-10	14.5	15.0	9.5	2.3
7-13	14.0	7.3	3.3	1.0
7-15	7.6	7.0	3.8	3.0
7-17	12.3	9.3	5.5	1.8
7-20	9.2	9.0	6.0	1.0
7-22	10.2	9.0	6.3	1.8
7-24	10.9	8.5	5.0	2.2
7-27	5.4	5.2	4.4	2.0

TABLE I (continued)

TYPE ANALYSIS: Dissolved Oxygen MONTH: July-August 1964

Date	1	2	3	4
7-29	3.5	4.1	4.2	1.1
7-31	6.2	5.4	3.0	2.5
8-3	4.0	5.0	3.5	2.1
8-5	3.6	3.3	4.6	1.0
8-7	6.0	5.7	4.9	1.8
8-10	7.0	4.5	4.3	2.4
8-12	2.6	2.1	1.6	1.0
8-14	3.5	3.3	2.1	0.5
8-17	7.8	6.8	4.6	2.4
8-19	5.6	6.2	4.0	1.2
8-21	3.6	3.8	1.7	2.3
8-24	2.7	2.5	2.8	2.3
8-26	3.1	4.4	2.5	0.8
8-28	6.6	4.8	4.5	1.2

TABLE II

TYPE ANALYSIS - Dissolved Oxygen MONTH - June-July 1965

	Marina Station			
Date	1	2	3	4
6-7	10.0	8.3	3.2	5.0
6-9	10.8	6.7	9.8	4.0
6-11	8.5	7.1	5.7	1.2
6-14	9.7	8.7	5.9	2.3
6-15	----	----	---	---
6-16	10.0	8.8	6.9	3.0
6-17	----	----	---	---
6-18	11.5	10.5	8.5	2.7
6-21	10.5	11.2	4.9	1.0
6-22	----	----	---	---
6-23	10.5	9.9	4.1	1.8
6-24	----	----	---	---
6-25	7.3	6.2	3.9	1.2
6-28	9.5	8.9	4.8	2.3
6-29	----	----	---	---
6-30	6.0	5.2	3.6	2.6
7-1	----	----	---	---
7-2	7.0	5.7	3.2	0.5
7-6	----	----	---	---
7-7	8.8	5.7	5.2	1.3
7-8	----	----	---	---
7-9	6.0	4.4	2.0	1.0
7-12	10.1	8.0	4.7	1.6

TABLE II (continued)

TYPE ANALYSIS - Dissolved Oxygen   MONTH - July-August 1965

Date	Marina Station 1	2	3	4
7-13	---	---	---	---
7-14	8.0	8.5	6.9	1.2
7-15	---	---	---	---
7-16	6.0	5.5	4.9	2.0
7-19	7.7	7.6	5.9	3.5
7-20	---	---	---	---
7-21	9.9	8.6	4.2	2.4
7-22	---	---	---	---
7-23	7.2	6.5	5.4	0.8
7-26	5.6	4.9	2.6	0.9
7-27	---	---	---	---
7-28	6.7	6.2	2.5	1.6
7-29	---	---	---	---
7-30	8.0	6.9	3.0	1.2
8-2	4.8	4.7	1.9	0.3
8-3	---	---	---	---
8-4	6.0	4.4	2.3	0.2
8-5	---	---	---	---
8-6	5.3	4.5	2.6	1.3
8-9	4.9	4.5	2.3	0.5
8-10	---	---	---	---
8-11	5.0	4.9	3.9	1.2
8-12	---	---	---	---

TABLE II (continued)

TYPE ANALYSIS - Dissolved Oxygen MONTH - August 1965

	Marina Station			
Date	1	2	3	4
8-13	8.2	7.0	3.4	0.3
8-16	6.0	5.8	1.2	5.6
8-17	---	---	---	---
8-18	4.6	4.0	2.1	0.8
8-19	---	---	---	---
8-20	2.6	2.1	1.6	0.7
8-23	0.5	0.7	1.0	0.7
8-24	---	---	---	---
8-25	5.4	3.6	2.4	0.6
8-26	---	---	---	---
8-27	3.0	1.8	1.5	0.1
8-30	---	---	---	---

TABLE III

TYPE ANALYSIS: Carbon Dioxide MONTH: June-July 1964

Date	Marina Station 1	2	3	4
6-8	0	5.0	10.0	10.0
6-10	0	5.0	10.0	10.0
6-12	0	5.0	10.0	15.0
6-15	5.0	10.0	5.0	10.0
6-17	10.0	5.0	5.0	15.0
6-19	5.0	5.0	10.0	15.0
6-22	5.0	10.0	15.0	15.0
6-24	5.0	5.0	10.0	15.0
6-26	5.0	10.0	5.0	20.0
6-29	5.0	10.0	15.0	20.0
7-1	10.0	10.0	15.0	15.0
7-3	10.0	10.0	15.	15.0
7-6	5.0	10.0	15.0	20.0
7-8	----	----	----	----
7-10	18.6	18.6	16.2	26.3
7-13	0.5	2.0	2.5	2.0
7-15	12.1	11.1	16.2	20.2
7-17	3.0	10.1	20.2	23.3
7-20	8.1	8.1	11.1	12.1
7-22	10.1	8.1	12.1	17.2
7-24	3.0	10.1	24.3	13.1
7-27	8.1	10.1	16.2	26.3

TABLE III (continued)

TYPE ANALYSIS: Carbon Dioxide MONTH: July-August 1964

Date	Marina Station 1	2	3	4
7-29	13.2	17.2	18.2	35.4
7-31	23.3	15.2	10.2	18.2
8-3	22.3	17.2	30.4	20.3
8-5	18.2	19.2	15.2	24.3
8-7	12.1	15.2	13.2	18.2
8-10	10.1	15.2	17.2	17.2
8-12	11.1	10.1	18.2	16.2
8-14	16.2	20.2	16.2	20.2
8-17	10.12	11.1	13.2	20.2
8-19	18.2	17.2	16.2	14.2
8-21	16.2	23.3	30.4	25.3
8-24	23.3	20.2	21.3	28.3
8-26	20.2	32.2	43.5	22.2
8-28	19.2	16.2	18.2	30.4

TABLE IV

TYPE ANALYSIS - Carbon Dioxide MONTH - June-July 1965

Date	Marina Station 1	2	3	4
6-7	Tr	7.6	8.5	4.2
6-9	Tr	0.4	Tr	1.0
6-11	Tr	Tr	2.12	5.30
6-14	Tr	Tr	2.34	6.36
6-15	---	---	---	---
6-16	Tr	Tr	Tr	10.6
6-17	---	---	---	---
6-18	5.0	Tr	Tr	5.0
6-21	Tr	Tr	5.2	8.5
6-22	---	---	---	---
6-23	5.3	Tr	3.18	8.5
6-24	---	---	---	---
6-25	Tr	Tr	2.1	6.3
6-28	Tr	Tr	3.18	6.36
6-29	---	---	---	---
6-30	3.18	2.12	5.30	7.42
7-1	---	---	---	---
7-2	---	5.2	3.18	7.12
7-6	---	---	---	---
7-7	Tr	3.18	2.12	6.36
7-8	---	---	---	---
7-9	10.6	5.3	4.24	10.6
7-12	---	---	---	---

TABLE IV (continued)

TYPE ANALYSIS - Carbon Dioxide   MONTH - July-August 1965

Date	Marina Station 1	2	3	4
7-13	---	---	---	---
7-14	2.12	2.12	2.12	8.48
7-15	---	---	---	---
7-16	4.08	3.06	6.12	3.06
7-19	Tr	Tr	2.20	3.06
7-20	---	---	---	---
7-21	Tr	2.06	3.06	5.05
7-22	---	---	---	---
7-23	1.02	2.04	3.06	4.08
7-26	2.04	4.08	4.08	---
7-27	---	---	---	---
7-28	3.06	2.04	4.08	4.08
7-29	---	---	---	---
7-30	3.06	2.04	4.08	3.06
8-2	5.10	3.06	5.10	5.10
8-3	---	---	---	---
8-4	3.06	3.06	3.06	3.06
8-5	---	---	---	---
8-6	4.08	6.00	6.12	3.06
8-9	5.10	5.10	5.10	10.2
8-10	---	---	---	---
8-11	---	---	---	---
8-12	---	---	---	---

TABLE IV (continued)

TYPE ANALYSIS - Carbon Dioxide MONTH - August 1965

Date	Marina Station 1	2	3	4
8-13	9.18	20.04	11.20	6.12
8-16	3.06	3.06	5.10	7.14
8-17	---	---	---	---
8-18	4.08	4.08	6.12	
8-19	---	---	---	---
8-20	10.2	5.1	4.08	7.14
8-23	7.4	5.1	6.36	8.96
8-24	---	---	---	---
8-25	6.12	7.14	8.16	6.12
8-26	---	---	---	---
8-27	5.1	6.12	5.1	5.1
8-30	---	---	---	---

TABLE V

TYPE ANALYSIS: pH MONTH: June-July 1964

Date	Marina Station 1	2	3	4
6-8	7.2	7.7	7.6	7.6
6-10	8.4	8.1	7.8	7.8
6-12	7.4	7.9	8.0	7.7
6-15	7.9	8.0	7.9	7.7
6-17	7.8	8.0	7.5	7.5
6-19	7.0	8.0	8.0	7.6
6-22	7.2	7.5	7.6	7.8
6-24	7.6	8.0	8.0	7.7
6-26	7.3	8.0	8.2	7.5
6-29	7.8	7.8	7.7	7.3
7-1	7.4	7.5	7.4	7.5
7-3	7.4	7.5	7.4	7.3
7-6	7.7	7.9	7.5	7.3
7-8	8.2	7.8	7.3	7.2
7-10	8.5	8.35	7.85	7.3
7-13	7.7	7.85	7.5	7.4
7-15	7.9	7.7	7.4	7.3
7-17	8.1	8.0	7.5	7.3
7-20	8.15	8.10	7.5	7.35
7-22	6.8	6.8	7.3	7.2
7-24	6.9	8.0	8.3	7.3
7-27	6.35	6.7	6.6	6.4

TABLE V (continued)

TYPE ANALYSIS: pH MONTH: July-August 1964

Date	Marina Station 1	2	3	4
7-29	7.45	7.5	7.5	7.2
7-31	7.6	7.1	7.3	7.4
8-3	7.4	7.5	7.3	7.3
8-5	7.5	7.45	7.5	7.3
8-7	7.8	7.7	7.75	7.4
8-10	7.7	7.6	7.5	7.4
8-12	7.5	7.5	7.5	7.4
8-14	7.4	7.5	7.5	7.0
8-17	7.9	7.7	7.6	7.4
8-19	7.9	7.8	7.5	7.5
8-21	7.5	7.5	7.5	7.5
8-24	7.3	7.3	7.3	7.2
8-26	7.4	7.4	7.3	7.3
8-28	7.6	7.4	7.4	7.3

TABLE VI

TYPE ANALYSIS - pH

MONTH - June-July 1965

Date	Marina Station 1	2	3	4
6-7	8.6	8.3	7.9	8.0
6-9	8.6	8.5	8.7	8.0
6-11	8.5	8.4	8.2	7.9
6-14	8.4	8.3	8.1	7.7
6-15	---	---	---	---
6-16	9.0	8.8	8.5	7.9
6-17	---	---	---	---
6-18	8.6	8.8	8.6	7.8
6-21	9.0	8.9	7.9	7.7
6-22	---	---	---	---
6-23	8.7	8.8	7.8	7.6
6-24	---	---	---	---
6-25	8.7	8.35	8.1	7.8
6-28	9.1	8.9	8.7	7.75
6-29	---	---	---	---
6-30	8.35	8.15	7.9	7.7
7-1	---	---	---	---
7-2	8.65	8.15	7.80	7.65
7-6	---	---	---	---
7-7	9.2	8.4	8.2	7.8
7-8	---	---	---	---
7-9	8.6	7.8	7.8	7.8
7-12	8.55	8.1	7.4	7.4

TABLE VI (continued)

TYPE ANALYSIS - pH

MONTH - July-August 1965

Date	Marina Station 1	2	3	4
7-13	---	---	---	---
7-14	8.4	8.1	7.9	7.43
7-15	---	---	---	---
7-16	8.0	7.9	7.4	7.6
7-19	8.6	8.5	8.15	7.8
7-20	---	---	---	---
7-21	8.7	8.4	7.5	7.4
7-22	---	---	---	---
7-23	8.0	8.1	7.4	7.4
7-26	7.95	7.95	7.8	7.6
7-27	---	---	---	---
7-28	7.8	7.9	7.45	7.45
7-29	---	---	---	---
7-30	7.5	7.3	7.4	7.4
8-2	7.8	7.9	7.6	7.5
8-3	---	---	---	---
8-4	7.8	7.75	7.6	---
8-5	---	---	---	---
8-6	---	---	---	---
8-9	8.0	7.9	7.8	7.75
8-10	---	---	---	---
8-11	7.8	7.9	7.7	7.5
8-12	---	---	---	---

TABLE VI (continued)

TYPE ANALYSIS - pH

MONTH - August
1965

Date	Marina Station 1	2	3	4
8-13	8.1	8.0	7.7	7.5
8-16	8.0	7.85	7.65	7.55
8-17	---	---	---	---
8-18	7.9	7.8	7.6	7.85
8-19	---	---	---	---
8-20	7.45	7.6	7.45	7.5
8-23	7.5	7.45	7.5	7.45
8-24	---	---	---	---
8-25	7.8	7.4	7.5	7.6
8-26	---	---	---	---
8-27	7.35	7.45	7.5	7.5
8-30	---	---	---	---

TABLE VII

TYPE ANALYSIS: B.O.D. (Marina) MG/L MONTH: June-July 1964

Date	Marina Station 1	2	3	4
6-8	----	----	----	----
6-10	15.3	9.0	6.9	4.6
6-12	----	----	----	----
6-15	10.2	7.2	6.2	21.2
6-17	34.2	18.8	18.8	12.1
6-19	20.0	12.6	9.4	13.1
6-22	3.3	1.7	1.7	2.8
6-24	11.0	20.4	2.8	9.4
6-26	18.8	19.2	23.3	7.3
6-29	14.4	14.4	4.4	5.5
7-1	9.9	7.7	7.7	28.2
7-3	12.3	4.9	2.04	5.3
7-6	19.3	6.6	5.5	7.2
7-8	21.0	7.9	3.9	10.5
7-10	22.6	17.8	13.2	8.3
7-13	35.9	19.9	24.8	18.8
7-15	8.4	8.7	7.5	6.0
7-17	10.2	5.8	8.9	6.2
7-20	6.9	5.6	6.9	9.6
7-22	9.3	13.2	8.7	13.8
7-24	12.0	7.8	10.8	5.7
7-27	8.3	6.3	5.3	3.6

TABLE VII (continued)

TYPE ANALYSIS: B.O.D. (Marina) MG/L MONTH: July-August 1964

Date	Marina Station 1	2	3	4
7-29	9.6	10.5	9.9	15.0
7-31	5.1	9.9	4.5	5.4
8-3	14.9	8.3	13.5	11.6
8-5	6.6	4.2	14.7	14.1
8-7	11.4	16.5	16.5	12.9
8-10	7.6	10.6	12.5	0.33
8-12	----	----	----	----
8-14	----	----	----	----
8-17	6.6	3.6	4.6	9.6
8-19	12.6	12.0	15.3	15.3
8-21	17.1	6.3	5.6	5.8
8-24	8.9	9.2	12.5	14.2
8-26	----	----	----	----
8-28	----	----	----	----

TABLE VIII

TYPE ANALYSIS - B.O.D. MONTH - June-July 1965

Date	Marina Station 1	2	3	4
6-7	11.2	3.3	4.84	3.8
6-9	3.18	3.0	5.19	---
6-11	---	---	---	---
6-14	4.6	2.5	3.3	1.32
6-15	---	---	---	---
6-16			8.1	
6-17	---	---	---	---
6-18	8.4	8.4	6.0	5.7
6-21	7.9	3.63	2.15	2.97
6-22	---	---	---	---
6-23	6.9	8.4	7.8	8.7
6-24	---	---	---	---
6-25	1.0	5.7	4.2	9.6
6-28	7.3	2.5	4.95	2.3
6-29	---	---	---	---
6-30	9.7	10.0	5.6	3.56
7-1	---	---	---	---
7-2	17.1	21.6	13.8	14.1
7-6	---	---	---	---
7-7	8.9	13.3	16.4	12.3
7-8	---	---	---	---
7-9	25.5	24.0	30.6	33.6
7-12	8.9	9.21	22.4	4.2

TABLE VIII (continued)

TYPE ANALYSIS - B.O.D.　　MONTH - July-August 1965

Date	Marina Station 1	2	3	4
7-13	----	---	----	---
7-14	11.7	9.0	14.0	2.4
7-15	----	---	----	---
7-16	----	---	----	---
7-19	10.6	12.5	10.0	7.3
7-20	----	---	----	---
7-21	20.6	20.0	19.8	8.4
7-22	----	---	----	---
7-23	14.4	9.6	8.7	6.9
7-26	----	---	----	---
7-27	----	---	----	---
7-28	13.4	9.4	18.6	4.8
7-29	----	---	----	---
7-30	13.9	11.2	12.5	4.2
8-2	10.7	13.2	----	---
8-3	----	---	----	---
8-4	17.4	17.3	12.9	9.9
8-5	----	---	----	---
8-6	6.1	6.1	4.1	5.6
8-9	12.2	5.1	4.1	4.6
8-10	----	---	----	---
8-11	12.0	---	----	3.0
8-12	----	---	----	---

TABLE VIII(continued)

TYPE ANALYSIS - B.O.D. MONTH - August 1965

Date	Marina Station 1	2	3	4
8-13	9.7	14.4	10.6	6.6
8-16	9.46	4.62	3.2	9.9
8-17	---	---	---	---
8-18	5.2	7.7	6.9	7.2
8-19	---	---	---	---
8-20	3.3	1.0	3.2	1.0
8-23	4.2	5.1	5.8	3.6
8-24	---	---	---	---
8-25	18.0	21.3	17.4	30.9
8-26	---	---	---	---
8-27				
8-30				

TABLE IX

TYPE ANALYSIS: Phosphates, MG/L MONTH: June-July 1964

Date	Marina Station 1	2	3	4
6-8	.7	.5	.9	1.2
6-10	1.0	1.8	3.3	2.8
6-12	1.5	1.6	1.7	1.80
6-15	1.6	2.0	2.3	4.10
6-17	1.2	1.2	1.9	1.5
6-19	1.4	0.8	1.6	5.0
6-22	0.95	1.25	1.45	1.35
6-24	1.2	2.0	2.8	1.4
6-26	0.40	0.19	0.57	1.86
6-29	0.23	0.12	0.59	0.64
7-1	0.38	0.62	1.04	1.50
7-3	0.95	0.87	1.59	1.10
7-6	0.25	0.25	1.30	1.62
7-8	----	----	----	----
7-10	----	----	----	----
7-10	----	----	----	----
7-13	----	----	----	----
7-15	0.30	0.28	0.57	1.76
7-17	0.64	0.46	0.57	1.66
7-20	0.81	0.62	0.42	1.15
7-22	0.50	0.92	2.34	2.08
7-24	1.50	0.71	1.97	0.34

TABLE IX (continued)

TYPE ANALYSIS: Phosphates, MG/L   MONTH: July-August

Date	Marina Station 1	2	3	4
7-29	1.45	1.20	0.98	3+
7-31	0.71	0.81	1.04	0.90
8-3	0.92	0.87	0.76	0.59
8-5	1.04	1.10	0.76	0.95
8-7	0.62	0.66	0.92	1.38
8-10	0.78	0.76	0.76	1.07
8-12	0.98	0.95	1.41	1.45
8-14	0.92	0.71	1.01	0.55
8-17	0.66	0.55	1.04	2.50
8-19	0.59	0.48	0.78	1.16
8-21	0.81	0.90	0.66	0.76
8-24	1.13	0.84	1.10	2.34
8-26	1.91	0.95	0.92	1.30
8-28	0.34	0.44	0.59	2.50

TABLE V

TYPE ANALYSIS - Phosphates MONTH - June-July 1965

Date	Marina Station 1	2	3	4
6-7	0.74	0.46	1.23	0.44
6-9	0.17	0.23	0.25	1.01
6-11	0.06	0.42	0.55	0.78
6-14	0.95	0.07	0.36	0.38
6-15	----	----	----	----
6-16	0.25	0.78	0.44	0.30
6-17	----	----	----	----
6-18	0.12	0.19	0.23	0.92
6-21	0.19	0.16	0.55	0.62
6-22	----	----	----	----
6-23	0.46	0.71	0.81	2.66
6-24	----	----	----	----
6-25	0.40	0.50	2.34	0.95
6-28	0.68	0.48	0.30	1.41
6-29	----	----	----	----
6-30	0.34	0.42	0.38	1.10
7-1	----	----	----	----
7-2	0.42	0.25	0.71	1.41
7-6	----	----	----	----
7-7	0.92	0.84	1.07	1.10
7-8	----	----	----	----
7-9	0.11	0.50	0.68	0.98
7-12	0.17	0.25	0.57	0.90

TABLE X (continued)

TYPE ANALYSIS - Phosphates   MONTH - July-August
1965

	Marina Station			
Date	1	2	3	4
7-13	----	----	----	----
7-14	0.67	0.30	0.34	1.27
7-15	----	----	----	----
7-16	0.26	0.38	0.42	1.23
7-19	0.16	0.19	0.30	0.25
7-20	----	----	----	----
7-21	0.07	0.23	0.55	0.62
7-22	----	----	----	----
7-23	0.12	0.36	0.71	0.92
7-26	0.59	1.23	0.81	0.95
7-27	----	----	----	----
7-28	0.34	0.40	0.71	0.44
7-29	----	----	----	----
7-30	0.19	0.26	0.34	0.74
8-2	0.68	0.66	0.78	0.50
8-3	----	----	----	----
8-4	0.84	0.68	0.76	1.54
8-5	----	----	----	----
8-6	0.84	0.92	0.95	2.14
8-9	0.81	0.74	0.78	0.98
8-10	----	----	----	----
8-11	0.59	0.57	0.64	1.62
8-12	----	----	----	----

TABLE X (continued)

TYPE ANALYSIS - Phosphates MONTH - August
1965

Date	Marina Station			
	1	2	3	4
8-13	0.53	0.74	0.92	1.72
8-16	0.76	0.71	0.98	1.23
8-17	----	----	----	----
8-18	0.81	0.84	0.92	1.13
8-19	----	----	----	----
8-20	0.90	1.20	1.10	1.27
8-23	1.13	0.92	1.07	1.07
8-24	----	----	----	----
8-25	0.87	0.78	0.78	2.27
8-26	----	----	----	----
8-27	1.23	1.23	1.13	1.13
8-30	----	----	----	----

TABLE XI

TYPE ANALYSIS - Nitrates   MONTH - June-July-August, 1964

Date	Marina Station			
	1	2	3	4
6-29	0.23	0.12	0.59	0.64
7-1	7.3	9.0	7.1	9.4
7-3	6.3	6.9	6.7	7.5
7-6	1.9	2.2	1.6	1.9
7-8	1.4	1.5	1.4	1.6
7-10	1.5	1.3	1.2	0.9
7-13	1.6	1.6	1.8	1.9
7-15	0.7	0.7	0.5	0.9
7-17	5.6	5.3	4.0	5.4
7-20	1.5	1.2	1.0	1.1
7-22	1.1	1.1	1.0	1.0
7-24	2.0	1.1	1.2	1.2
7-27	4.8	5.1	3.5	5.1
7-29	4.8	5.1	3.5	5.1
7-31	1.3	1.0	1.0	1.1
8-3	1.0	0.7	0.1	1.0
8-5	1.2	1.0	1.5	1.2
8-7	1.1	0.8	1.4	0.7
8-10	1.5	1.1	1.2	1.6
8-12	0.1	0.1	0.7	1.0
8-14	0.1	1.0	0.7	1.0
8-17	0.1	0.5	0.8	0.7
8-19	1.0	0.1	1.0	1.0

TABLE XI

TYPE ANALYSIS - Nitrates MONTH - June-July-August, 1964

Date	Marina Station 1	2	3	4
8-21	0.3	0.1	0.5	2.3
8-24	2.0	1.4	1.3	2.8
8-26	1.0	0.6	1.5	1.0
8-28	0.7	0.5	2.1	0.1

TABLE XII

TYPE ANALYSIS - Nitrates   MONTH - June-July-August, 1965

	Marina Station			
Date	1	2	3	4
6-7	1.9	1.9	1.4	1.[illegible]
6-9	2.2	1.6	1.5	1.2
6-11	2.1	2.1	2.3	1.5
6-14	1.3	1.8	2.2	1.8
6-15	---	---	---	---
6-16	2.6	1.9	1.9	2.4
6-17	---	---	---	---
6-18	1.4	2.2	2.3	2.1
6-21	1.2	1.1	1.3	1.5
6-22	---	---	---	---
6-23	1.5	1.5	1.3	4.5
6-24	---	---	---	---
6-25	1.5	1.3	1.6	2.2
6-28	1.5	1.3	1.4	1.9
6-29	---	---	---	---
6-30	2.3	2.1	2.1	1.4
7-1	---	---	---	---
7-2	1.9	2.1	1.4	1.9
7-6	---	---	---	---
7-7	1.0	1.2	1.1	0.6
7-8	---	---	---	---
7-9	1.3	1.5	1.9	1.5
7-12	1.3	1.9	1.8	1.4

TABLE XII (continued)

TYPE ANALYSIS - Nitrates   MONTH - June-July-August
1965

Date	Marina Station 1	 2	 3	 4
7-13	---	---	---	---
7-14	1.5	1.8	1.8	1.8
7-15	---	---	---	---
7-16	1.0	1.3	1.1	1.0
7-19	1.6	1.4	1.2	1.1
7-20	---	---	---	---
7-21	1.4	1.5	1.0	1.4
7-22	---	---	---	---
7-23	1.6	1.3	1.1	1.3
7-26	0.8	1.0	0.7	0.6
7-27	---	---	---	---
7-28	1.0	0.9	0.7	0.6
7-29	---	---	---	---
7-30	1.1	1.1	1.0	0.5
8-2	1.2	1.0	1.0	0.7
8-3	---	---	---	---
8-4	0.9	1.0	0.6	---
8-5	---	---	---	---
8-6	1.0	0.6	0.7	0.4
8-9	1.0	1.2	1.3	0.6
8-10	---	---	---	---
8-11	0.6	0.9	0.5	0.3
8-12	---	---	---	---

TABLE XII (continued)

TYPE ANALYSIS - Nitrates MONTH - June-July-August 1965

Date	Marina Station 1	2	3	4
8-13	0.8	0.5	1.2	2.6
8-16	1.1	0.8	0.6	0.4
8-17	---	---	---	---
8-18	0.7	1.0	1.1	1.2
8-19	---	---	---	---
8-20	0.3	0.1	0.2	0.1
8-23	0.7	0.5	0.4	0.5
8-24	---	---	---	---
8-25	0.8	0.5	0.7	0.5
8-26	---	---	---	---
8-27	0.5	2.2	0.4	1.1
8-30	---	---	---	---

TABLE XIII

TYPE ANALYSIS - Total number of viable bacteria per ml.-1000's

MONTH - June-July-August,1964

Date	Marina Station 1	2	3	4
6-10	41	65	82	110
6-12	53	48	45	47
6-15	160	31	46	140
6-17	35	53	48	84
6-19	160	62	73	160
6-22	90	70	50	63
6-24	34	41	66	84
6-26	67	56	61	64
6-29	87	17	17	39
7-1	45	13	33	42
7-3	75	20	25	39
7-6	80	40	26	100
7-8	98	110	100	100
7-10	110	75	130	220
7-15	130	50	51	140
7-17	120	100	110	150
7-20	43	12	21	94
7-22	120	73	56	89
7-24	140	44	33	140
7-27	100	13	23	32
7-29	23	22	15	110
7-31	55	68	88	100

TABLE XIII (continued)

TYPE ANALYSIS - Total number of viable bacteria per ml.-1000's

MONTH - June-July-August,1964

Date	Marina Station 1	2	3	4
8-3	80	26	27	130
8-5	250	58	50	120
8-7	92	62	64	150
8-10	100	56	51	37
8-12	140	120	180	160
8-14	420	96	96	110
8-17	68	62	34	51
8-19	410	150	58	110
8-21	610	120	187	170
8-24	440	91	50	100
8-26	180	84	120	170
8-28	120	98	80	140

TABLE XIV

TYPE ANALYSIS - Total number of viable bacteria per ml.-1000's MONTH - June-July 1965

	Marina Station			
Date	1	2	3	4
6-7	37	87	39	160
6-9	11	39	15	43
6-11	130	72	41	81
6-14	220	76	70	66
6-16	230	70	45	64
6-18	360	62	43	115
6-21	41	60	33	38
6-23	35	90	60	150
6-25	58	64	70	160
6-28	13	51	92	160
6-30	810	72	120	120
7-2	90	89	100	100
7-7	140	48	57	150
7-9	13	37	64	230
7-12	10	36	37	180
7-14	15	41	39	100
7-16	27	35	57	390
7-19	67	93	72	70
7-21	97	67	65	98
7-23	360	54	46	180
7-26	280	170	79	500
7-28	12	20	30	610
7-30	200	160	120	63

TABLE XIV (continued)

TYPE ANALYSIS - Total number of viable bacteria per ml.-1000's MONTH - August 1969

Date	Marina Station 1	2	3	4
8-2	21	50	58	84
8-4	430	63	130	570
8-6	160	54	53	200
8-9	69	68	35	300
8-11	180	68	29	200
8-13	110	78	120	350
8-16	200	49	110	190
8-18	20	60	130	1,700
8-20	280	65	270	960
8-23	150	440	370	200
8-25	350	110	190	590
8-27	170	130	110	380
Average:	154	81	86	270

TABLE XV

TYPE ANALYSIS - Most probable number of coliform organisms per 100 ml.

MONTH _ June-July August, 1964

	Marina Station			
Date	1	2	3	4
6-10	17,000	79,000	240,000	350,000
6-12	49,000	23,000	23,000	70,000
6-15	790,000	23,000	8,000	170,000
6-17	8,000	33,000	70,000	130,000
6-19	240,000	49,000	79,000	540,000
6-22	33,000	17,000	13,000	540,000
6-24	110,000	13,000	49,000	70,000
6-26	23,000	8,000	350,000	542,000
6-29	13,000	8,000	13,000	17,000
7-1	2,000	2,000	2,000	4,000
7-3	23,000	13,000	13,000	8,000
7-6	790,000	130,000	49,000	79,000
7-8	79,000	79,000	79,000	130,000
7-10	49,000	33,000	23,000	79,000
7-13	240,000	130,000	46,000	70,000
7-15	110,000	790,000	33,000	220,000
7-17	240,000	280,000	49,000	130,000
7-20	13,000	13,000	8,000	23,000
7-22	49,000	49,000	33,000	23,000
7-24	49,000	5,000	5,000	33,000
7-27	13,000	5,000	2,000	23,000
7-29	13,000	13,000	17,000	100,000
7-31	24,000	13,000	24,000	24,000

TABLE XV (continued)

TYPE ANALYSIS - **Most probable number of** coliform organisms per 100 ml.

MONTH June-July August, 1968

Date	Marina Station 1	2	3	4
8-3	4,900	13,000	35,000	24,000
8-5	7,900	2,700	2,300	7,900
8-7	2,300	7,900	35,000	100,000
8-10	24,000	7,900	35,000	54,000
8-12	13,000	35,000	100,000	24,000
8-14	24,000	35,000	79,000	100,000
8-17	2,300	7,00	7,900	17,000
8-19	7,900	14,000	4,900	130,000
8-21	35,000	54,000	24,000	54,000
8-24	24,000	3,300	1,300	24,000
8-26	13,000	4,900	22,000	79,000
8-28	7,900	24,000	3,300	79,000

TABLE XVI

TYPE ANALYSIS - Most probable number of coliform organisms per 100 ml. MONTH - June-July 1965

Date	Marina Station 1	2	3	4
6-7	2,000	17,000	4,000	130,000
6-9	2,000	2,000	2,000	33,000
6-11	500	800	200	< 200
6-14	35,000	2,300	7,900	4,900
6-16	7,900	3,300	13,000	35,000
6-18	3,300	2,300	4,900	130,000
6-21	3,300	35,000	79,000	79,000
6-23	11,000	3,300	35,000	130,000
6-25	35,000	54,000	13,000	240,000
6-28	3,300	7,900	17,000	240,000
6-30	24,000	7,900	7,900	35,000
7-2	7,000	7,900	13,000	130,000
7-7	7,900	800	4,900	79,000
7-9	2,300	3,300	4,900	130,000
7-12	7,000	2,300	3,300	35,000
7-14	500	4,900	3,300	240,000
7-16	2,300	3,300	2,700	79,000
7-19	3,300	800	1,300	2,300
7-21	2,200	4,900	13,000	35,000
7-23	4,900	4,900	11,000	70,000
7-26	54,000	4,900	24,000	35,000
7-28	2,300	4,900	3,300	11,000
7-30	2,300	7,900	4,900	11,000

TABLE XVI

TYPE ANALYSIS - Most probable number of coliform organisms per 100 ml. MONTH- August 1965

Date	Marina Station			
	1	2	3	4
8-2	7,900	4,900	11,000	79,000
8-4	2,300	4,900	24,000	240,000
8-6	2,300	3,300	2,300	35,000
8-9	4,900	2,300	3,300	7,900
8-11	4,900	2,300	24,000	350,000
8-13	3,100	13,000	24,000	35,000
8-16	79,000	54,000	130,000	24,000
8-18	7,900	13,000	17,000	31,000
8-20	2,300	24,000	790,000	79,000
8-23	79,000	54,000	35.000	33,000
8-25	24,000	7,900	13,000	130,000
8-27	33,000	2,700	4,600	79,000
Average:	13,000	11,000	39,000	87,000

TABLE XVII

TYPE ANALYSIS - Total number of phytoplankton per ml.

MONTH - June-July-August 1964

Date	Marina Station 1	2	3	4
6-26	14,800	6,200	4,800	2,900
6-29	9,300	5,200	3,800	2,100
7-1	2,400	1,700	1,300	1,000
7-3	2,800	2,200	1,500	800
7-6	13,800	12,100	2,500	1,400
7-8	8,900	5,000	2,600	1,900
7-10	9,900	7,400	4,400	2,000
7-13	5,000	3,600	2,600	1,500
7-15	2,800	2,700	2,200	1,800
7-17	11,500	8,00	4,700	900
7-20	11,800	12,700	7,100	2,000
7-22	14,400	15,300	12,700	6,300
7-24	12,700	15,600	9,700	4,600
7-27	12,700	11,400	9,500	5,000
7-29	5,500	3,800	3,100	1,800
7-31	5,700	4,000	4,000	5,700
8-3	5,200	3,900	4,200	4,800
8-5	4,100	4,500	4,500	6,000
8-7	10,300	5.300	4,800	4,500
8-10	8,900	7,200	3,200	5,000
8-12	3,200	3.200	3,200	4,000
8-14	3,500	2,500	1,900	3,200

TABLE XVII

TYPE ANALYSIS - Total number of phytoplankton per ml.

MONTH - June-July-August 1964

Date	Marina Station 1	2	3	4
8-17	12,000	7,200	7,300	4,600
8-19	2,800	4,300	4,200	3,500
8-21	4,600	3,200	4,200	3,200
8-24	3,600	3,500	4,500	3,000
8-26	2,500	3,600	3,400	2,800
8-26	5,800	5,100	4,200	1,900

TABLE XVIII

TYPE ANALYSIS - Total number of phytoplankton per ml.

MONTH - June-July 1965

Date	Marina Station			
	1	2	3	4
6-7	5,000	4,800	3,300	1,600
6-9	3,100	3,100	3,900	1,600
6-11	10,000	5,000	3,300	3,000
6-14	11,000	8,000	6,000	2,700
6-16	16,000	12,000	6,600	1,500
6-18	15,000	11,000	7,000	2,600
6-21	21,000	14,000	5,100	1,800
6-23	16,000	16,000	5,600	4,300
6-25	12,000	7,600	4,900	2,100
6-28	18,000	11,000	6,200	2,400
6-30	11,000	7,200	3,000	2,300
7-2	10,000	4,600	3,200	2,000
7-7	11,000	5,600	3,100	2,200
7-9	10,000	5,600	5,000	1,600
7-12	9,800	7,700	4,700	3,000
7-14	9,000	5,600	4,800	2,100
7-16	7,600	4,100	4,100	1,700
7-19	9,000	7,200	3,700	3,600
7-21	10,000	7,700	3,600	3,700
7-23	6,300	5,300	4,200	2,600
7-26	6,800	5,500	3,700	3,000
7-28	5,400	5,800	3,000	2,400
7-30	8,200	5,700	4,200	1,800

TABLE XVIII (continued)

TYPE ANALYSIS - Total number of phytoplankton per ml.

MONTH - August 1965

Date	Marina Station 1	2	3	4
8-2	4,300	3,400	2,800	1,300
8-4	2,500	3,300	1,900	1,000
8-6	1,600	2,000	2,000	2,800
8-9	4,600	3,000	2,500	1,200
8-11	3,500	2,200	1,600	1,200
8-13	6,100	5,500	4,700	3,000
8-16	5,200	4,200	2,900	1,400
8-18	2,300	1,600	1,000	2,100
8-20	1,000	1,900	2,600	2,700
8-23	3,600	3,300	3,700	3,400
8-25	2,400	3,700	4,800	4,200
8-27	1,700	1,900	2,200	2,100
Average	8,000	5,900	3,900	2,300

TABLE XIX

TYPE ANALYSIS - Most probable number of enterococci per 100 ml.

MONTH - June-July 1955

Date	Marina Station			
	1	2	3	4
6-7	110	130	490	490
6-9	790	170	110	330
6-11	790	790	230	790
6-14	490	330	790	330
6-16	490	330	330	2,400
6-18	330	330	220	5,400
6-21	130	410	460	1,700
6-23	340	270	1300	5,400
6-25	210	220	3500	2,400
6-28	230	230	230	7,900
6-30	130	130	330	700
7-2	110	170	490	13,000
7-7	130	130	130	2,400
7-9	80	20	110	1,100
7-12	20	130	110	330
7-14	110	490	490	3,500
7-16	50	130	130	330
7-19	790	110	130	400
7-21	20	110	460	490
7-23	80	130	330	2,400
7-26	20	80	220	490
7-28	230	230	310	790
7-30	80	330	130	1,300

TABLE XIX (continued)

TYPE ANALYSIS - Most probable number of enterococci per 100 ml.

MONTH - August

Date	Marina Station 1	2	3	4
8-2	50	1,100	3,500	13,000
8-4	<20	80	220	24,000
8-6	70	130	80	3,500
8-9	70	110	330	7,900
8-11	20	20	50	7,900
8-13	1,100	790	1,300	28,000
8-16	24,000	130	80	400
8-18	230	790	170	14,000
8-20	3,500	3,500	2,200	4,900
8-23	390	260	120	700
8-25	24,000	2,100	240	54,000
8-27	22,000	2,500	170	2,200
Average	2,300		560	6,100

TABLE XX

AVERAGE NUMBERS OF BACTERIA, COLIFORMS, ENTEROCOCCI, AND PHYTOPLANKTON AT THE FOUR SAMPLING STATIONS 1965

Station	Total viable bacteria per ml.	Most probable number of coliforms per 100 ml.	Most probable number of enterococci per 100 ml.	Total number phytoplankton per ml.
1	154,000	13,000	2,300	8,000
2	81,000	11,000	480	5,900
3	86,000	39,000	560	3,900
4	270,000	87,000	6,100	2,300

TABLE XXI

TYPE ANALYSIS: Turbidity - Units MONTH: June-July
1964

Date	Marina Station 1	2	3	4
6-8	130	140	350	100
6-10	130	135	155	115
6-12	90	130	280	120
6-15	90	120	160	95
6-17	90	100	170	60
6-19	125	145	130	85
6-22	100	75	60	45
6-24	90	100	250	200
6-26	86	68	72	80
6-29	49	54	73	49
7-1	64	80	59	60
7-3	81	84	95	61
7-6	71	73	134	61
7-8	54	75	48	36
7-10	71	61	84	31
7-13	54	68	51	71
7-15	49	75	86	77
7-17	26	30	56	51
7-20	68	53	59	44
7-22	84	88	175	101
7-24	54	47	65	81
7-27	99	92	114	84

TABLE XXI (continued)

TYPE ANALYSIS: Turbidity - Units MONTH: July-August
1964

Date	Marina Station 1	2	3	4
7-29	75.0	95.0	61.0	25.0
7-31	68.0	65	77.0	65.0
8-3	59.0	84.0	90.0	99.0
8-5	61.0	75.0	81.0	117.0
8-7	64	68	84	65
8-10	86	65	73	42
8-12	47	51	49	54
8-14	42	65	44	120
8-17	64	59	75	59
8-19	47	54	65	65
8-21	61	64	81	68
8-24	49	54	56	77
8-26	193	54	81	90
8-28	56	65	50	56

TABLE XXII

TYPE ANALYSIS - Turbidity MONTH - June-July 1965

Date	Marina Station 1	2	3	4
6-7	35	22	[illegible]	56
6-9	44	42	[illegible]	51
6-11	71	80	71	75
6-14	61	71	66	64
6-15	--	--	--	--
6-16	120	77	84	90
6-17	--	--	--	--
6-18	--	--	--	--
6-21	59	61	58	61
6-22	--	--	--	--
6-23	61	58	65	56
6-24	--	--	--	--
6-25	54	59	56	42
6-28	54	61	61	65
6-29	--	--	--	--
6-30	49	49	56	30
7-1	--	--	--	--
7-2	49	40	49	36
7-6	--	--	--	--
7-7	56	54	65	35
7-8	--	--	--	--
7-9	47	17	44	[illegible]
7-10	47	41	47	35

TABLE XXII (continued)

TYPE ANALYSIS - Turbidity MONTH - July-August 1965

Date	Marina Station			
	1	2	3	4
7-13	--	--	--	--
7-14	47	51	51	36
7-15	--	--	--	--
7-16	49	47	42	30
7-19	47	51	54	42
7-20	--	--	--	--
7-21	51	49	44	26
7-22	--	--	--	--
7-23	42	75	75	86
7-26	39	36	3-	26
7-27	--	--	--	--
7-28	47	49	54	39
7-29	--	--	--	--
7-30	44	36	32	30
8-2	39	47	44	42
8-3	--	--	--	--
8-4	36	32	36	42
8-5	--	--	--	--
8-6	26	30	54	56
8-9	30	26	22	26
8-10	--	--	--	--
8-11	47	44	42	36
8-12	--	--	--	--

TABLE XXII (continued)

TYPE ANALYSIS - Turbidity MONTH - August
1965

Date	Marina Station 1	2	3	4
8-13	42	30	30	30
8-16	30	36	20	26
8-17	--	--	--	--
8-18	49	39	44	30
8-19	--	--	--	--
8-20	44	51	51	12
8-23	32	39	49	44
8-24	--	--	--	--
8-25	36	42	36	44
8-26	--	--	--	--
8-27	30	26	42	65
8-30	--	--	--	--

TABLE XXIII

TYPE ANALYSIS: Water Level - Above Datum MONTH: June-July-August
1964

Date	Level*	Date	Level*
6-8	1.28	7-29	0.60
6-10	0.89	7-31	1.13
6-12	1.25	8-3	0.95
6-15	0.98	8-5	1.17
6-17	1.23	8-7	0.53
6-19	0.86	8-10	0.97
6-22	1.28	8-12	0.48
6-24	0.37	8-14	0.37
6-26	0.83	8-15	0.69
6-29	0.97	8-16	0.62
7-1	0.72	8-17	0.45
7-3	0.72	8-18	0.70
7-6	1.18	8-19	0.63
7-8	1.25	8-20	0.55
7-10	0.95	8-21	0.85
7-13	0.41	8-22	0.73
7-15	0.91	8-23	0.20
7-17	0.90	8-24	0.55
7-20	1.00	8-25	0.40
7-22	0.93	8-26	0.57
7-24	1.02	8-27	1.01
7-27	0.94	8-28	0.61
		8-29	0.82

* Water level relative to 568.7 ft. above sea level

TABLE XXIV

TYPE ANALYSIS: Water Level - Above Datum Month: June-July-August
1965

Date	Level*
6-1	1.25
6-2	2.04
6-3	1.96
6-4	2.00
6-5	1.57
6.6	1.23
6.7	1.35
6.8	1.33
6.9	1.37
6-10	1.42
6-11	1.53
6-12	1.51
6-13	1.44
6-14	1.81
6-15	2.50
6-16	2.12
6.17	1.45
6-18	1.26
6-19	1.26
6-20	1.08
6-21	1.19
6-22	1.38
6-23	0.85
6-24	1.54
6-25	1.43
6-26	1.90
6-27	1.29
6-28	0.86
6-29	1.05
6-30	1.38
7-1	1.50
7-2	0.86
7-3	0.96
7-4	1.34
7-5	1.31
7-6	1.64
7-7	0.87
7-8	1.25
7-9	1.25
7-10	1.45
7-11	1.38
7-12	1.30
7-13	1.12
7-14	0.83
7-15	1.30
7-16	0.95

* water level relative to 568.7 ft. above sea level

TABLE XXIV (Continued)

TYPE ANALYSIS: Water Level - Above Datum MONTH: June-July-August 1969

Date	Level*	Date	Level*
7-17	1.19	8-9	0.49
7-18	1.38	8-10	0.96
7-19	1.55	8-11	1.09
7-20	1.51	8-12	0.69
7-21	1.29	8-13	0.53
7-22	1.15	8-14	0.90
7-23	1.23	8-15	0.87
7-24	1.01	8-16	1.14
7-25	1.19	8-17	0.88
7-26	1.15	8-18	0.98
7-27	0.93	8-19	1.17
7-28	1.06	8-20	0.99
7-29	1.13	8-21	1.35
7-30	1.21	8-22	0.97
7-31	1.15	8-23	1.29
8-1	0.85	8-24	0.97
8-2	0.51	8-25	1.07
8-3	0.90	8-26	0.60
8-4	0.92	8-27	0.63
8-5	1.08	8-28	0.17
8-6	0.92	8-29	0.64
8-7	0.87		
8-8	0.92		

*Water level relative to 568.7 ft. above sea level

TABLE XXV

TYPE ANALYSIS: Water Temperature (°C) MONTH: June-July 1964

Date	Marina Station 1	2	3	4
6-8	21.1	20.6	20.0	20.6
6-10	23.3	23.3	22.2	21.7
6-12	21.1	21.1	21.1	20.6
6-15	22.2	24	23.3	22.7
6-17	21.1	21.1	21.1	22.2
6-19	24	24	23.3	23.3
6-22	24	24	24	24.4
6-24	24	25	25	25
6-26	25	25	25	24.5
6-29	26.5	26.0	26.5	26.5
7-1	26.5	26.0	26.0	26.0
7-3	27.0	27.0	27.0	26.5
7-6	25.5	26.0	26.0	26.0
7-8	25.0	25.0	25.5	26.0
7-10	25.0	25.0	25.5	26.0
7-13	23.0	23.5	24.0	24.0
7-15	23.5	23.0	23.0	23.5
7-17	25	25	25	25
7-20	28	28	28	28
7-22	28	28.5	28.5	28.5
7-24	28.5	28.5	29.0	29.0
7-27	28.5	28.5	29.0	29.0

TABLE XXV (continued)

TYPE ANALYSIS: Water Temperature (°C) MONTH: July-August 1964

Date	Marina Station 1	2	3	4
7-27	28.5	28.5	29.0	29.0
7-29	28.3	28.3	28.3	28.9
7-31	25.5	25.5	25.5	25.5
8-3	27.5	27.0	27.0	27.0
8-5	26.5	27.0	27.0	27.0
8-7	25.5	25.5	26.0	27.0
8-10	24.0	24.0	24.5	24.5
8-12	23	23	23	23
8-14	----	----	----	----
8-17	22.0	22.0	22.5	23.0
8-19	21.0	21.5	22.0	22.0
8-21	21.5	21.5	22.0	22.0
8-24	21.5	21.5	22.0	22.0
8-26	20.5	21.0	22.0	22.0
8-28	23.0	23.0	23.5	23.5

TABLE XXVI

TYPE ANALYSIS - Temperature °C [illegible] – June-July
1966

Date	Marine Station 1	 2	 3	 4
6-7	22	22	22	22
6-9	23	23	23	23
6-11	23	23	23	23
6-14	23	23	23	23
6-15	---	---	---	---
6-16	22	22	22	22
6-17	---	---	---	---
6-18	22	22	22	22
6-21	23.5	23.5	23.5	23
6-22	---	---	---	---
6-23	24.5	24.5	24.5	24.5
6-24	---	---	---	---
6-25	23	23	23	23
6-28	24.5	24.5	25	24
6-29	---	---	---	---
6-30	23	23.5	23.5	23.5
7-1	---	---	---	---
7-2	23	23	23.5	24
7-6	---	---	---	---
7-7	23.5	23.5	23.5	24
7-8	---	---	---	---
7-9	24	24	24	24
7-12	---	---	---	---

TABLE XXVI (continued)

TYPE ANALYSIS - Temperature °C   MONTH - July-August 1965

Date	Marina Station 1	2	3	4
7-13	----	----	----	----
7-14	25.2	25.4	25.6	25.4
7-15	----	----	----	----
7-16	23.7	24.2	24.7	25.2
7-19	23.5	24	24.5	24
7-20	----	----	----	----
7-21	23	23	23	24
7-22	----	----	----	----
7-23	25	25	25	25
7-26	25	25	25	25
7-27	----	----	----	----
7-28	24	24	25	25
7-29	----	----	----	----
7-30	23	23	23	24
8-2	23	23	23	23
8-3	----	----	----	----
8-4	23	22	22	22
8-5	----	----	----	----
8-6	23	23.5	23.5	24
8-9	----	----	----	----
8-10	----	----	----	----
8-11	22	23	23	23
8-12	----	----	----	----

TABLE XXVI (continued)

TYPE ANALYSIS - Temperatures °C MONTH - August 1965

Date	Marina Station 1	2	3	4
8-13	23.5	23.5	23.5	23.5
8-16	25	25	25	25
8-17	----	----	----	----
8-18	25.5	25.5	25.5	26.0
8-19	----	----	----	----
8-20	24	24	24	24
8-23	23	23	23	23
8-24	----	----	----	----
8-25	23	23	23	23
8-26	----	----	----	----
8-27	23	23	23	23
8-30	----	----	----	----

TABLE XXVII

TYPE ANALYSIS: Climatology MONTH: June--July 1964

Date	Dir.	M.P.H.	Air Temp °C	Precip. In.
6-8	E	6.1	22.8	0
6-10	SW	12.8	20.5	0
6-12	SW	8.4	20.5	0.19
6-15	SW	13.6	18.3	0.39
6-17	SE	4.9	14.4	0
6-19	SW	12.6	27.2	0.23
6-22	E	5.0	22.2	0
6-24	SW	13.8	18.8	0
6-26	SW	10.1	24.4	0
6-29	S	5.2	25.5	0
7-1	NW	7.3	25.0	0.19
7-3	NW	9.4	24.4	0.20
7-6	SW	5.7	19.4	Trace
7-8	N	6.7	21.7	Trace
7-10	NE	5.6	22.8	0
7-13	SW	10.8	18.8	Trace
7-15	NW	5.9	22.2	0.06
7-17	SW	6.3	24.4	0
7-20	N	5.9	27.8	0
7-22	NE	6.5	27.2	0
7-24	SE	5.0	25.6	0
7-27	SW	6.2	26.1	0

TABLE XXVII(continued)

TYPE ANALYSIS: Climatology

MONTH: July-August 1964

Date	Dir.	M.P.H.	Air Temp °C	Precip. In.
7-29	N	11.7	19.0	0
7-31	E	8.5	21.0	0
8-3	SW	10.8	27.8	0.42
8-5	N	9.3	21.0	0
8-7	SW	5.5	23.0	0.10
8-10	SE	5.9	19.0	Trace
8-12	NW	11.1	15.0	0.02
8-14	W	6.9	13.8	0
8-15	W	14.4	0.7	0.8
8-16	NW	16.5	0.42	0.03
8-17	SW	20.0	Trace	0.42
8-18	SW	19.0	0	0.01
8-19	N	16.9	0	0.19
8-20	N	13.8	0.1	0.42
8-21	SE	21.0	0.2	0.2
8-22	SW	18.0	0	0
8-23	WSW	16.0	Trace	0
8-24	W	18.0	0.75	0
8-25	W	17.0	0.02	0
8-26	ESE	15.0	0.02	0
8-27	ESE	13.8	0	0
8-28		18.0	0	0.27

TABLE XXVIII

TYPE ANALYSIS: Climatology MONTH: June-July-August
1965

Date	Dir.	M.P.H.	Air Temp. °C	Precip. In.
6-7	S	6.8	19	0.07
6-9	W	4.2	23	0
6-11	E	5.6	22	0
6-14	E	7.9	17	0
6-16	NE	11.9	19	Trace
6-18	NW	9.4	18	Trace
6-21	W	8.9	24	0.25
6-23	SW	10.6	24.5	0.35
6-25	E	6.9	18	0
6-28	NW	12.1	26	0.52
6-30	N	8.8	20	0
7-2	SW	12.0	19.5	0.09
7-7	S	7.5	22	0.76
7-9	SW	12.5	24	Trace
7-12	--	Calm	20	0
7-14	SW	17.5	26.4	0.09
7-16	W	5.0	20.7	0.19
7-19	E	10.0	20	0
7-21	S-SE	2.5	20	0
7-23	NW	9.6	24	0.54
7-26	NW	7.8	21	0
7-28	N	8.9	22	0
7-30	N	4.9	17	0

TABLE XXVIII

TYPE ANALYSIS: Climatology

MONTH: June-July
August, 1965

Date	Dir.	M.P.H.	Air Temp. °C	Precip. In.
8-2	NW	12.5	17	0.04
8-4	SW	6.1	19	0.16
8-6	SW	9.5	25	Trace
8-9	SW	11.8	20	0.04
8-11	SW	4.1	17	0
8-13	W	11.9	22	0
8-16	N	6.2	24	0.72
8-18	NW	6.9	23	0.15
8-20	SE	4.7	17	0
8-23	NE	7.2	17	0
8-25	N	3.8	23	1.32
8-27	W	12.9	21	1.35

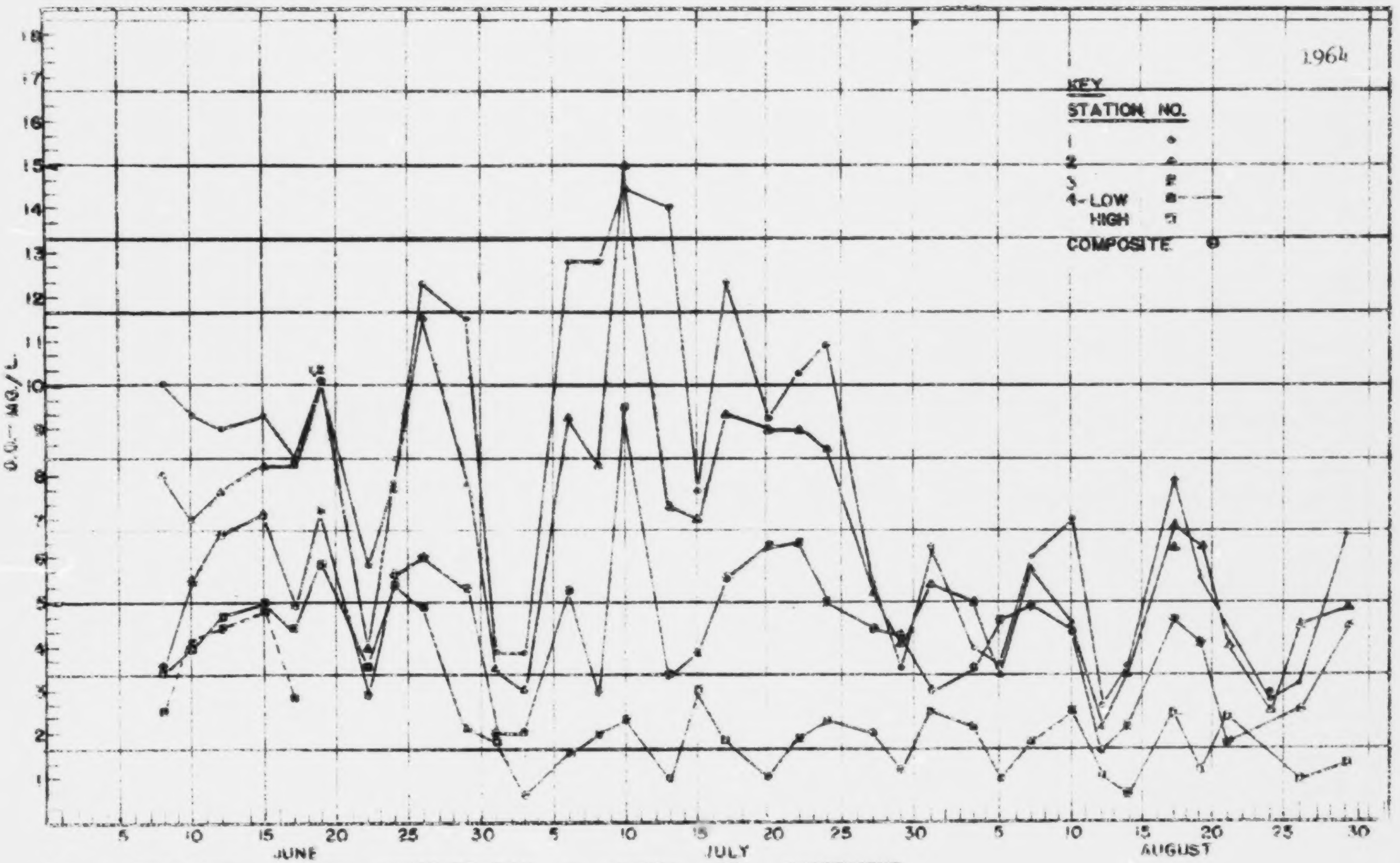


FIG. 2 DISSOLVED OXYGEN CONCENTRATION IN MARINA AREA EXPERIMENT

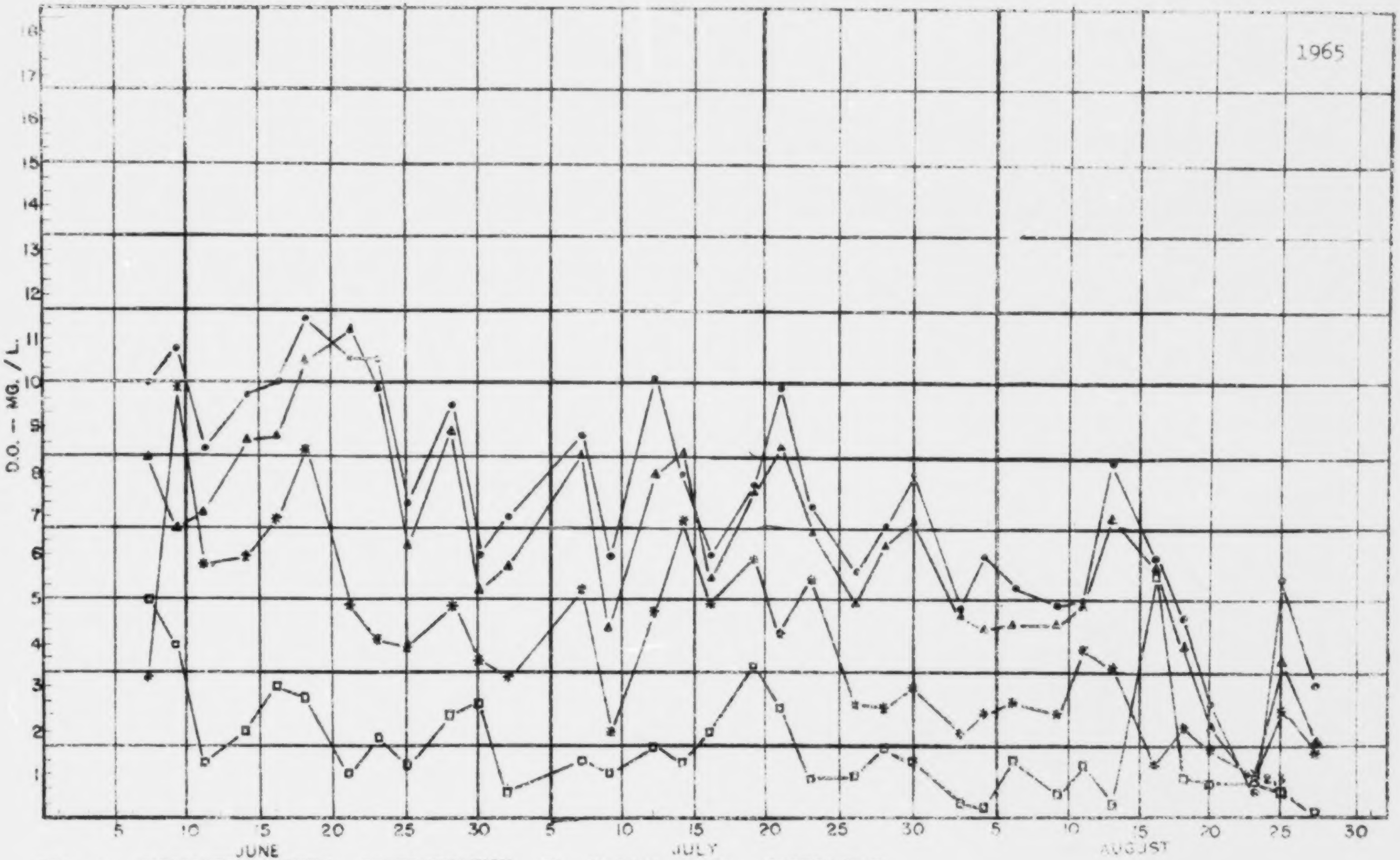


FIG. 3 DISSOLVED OXYGEN CONCENTRATION IN MARINA AREA EXPERIMENT

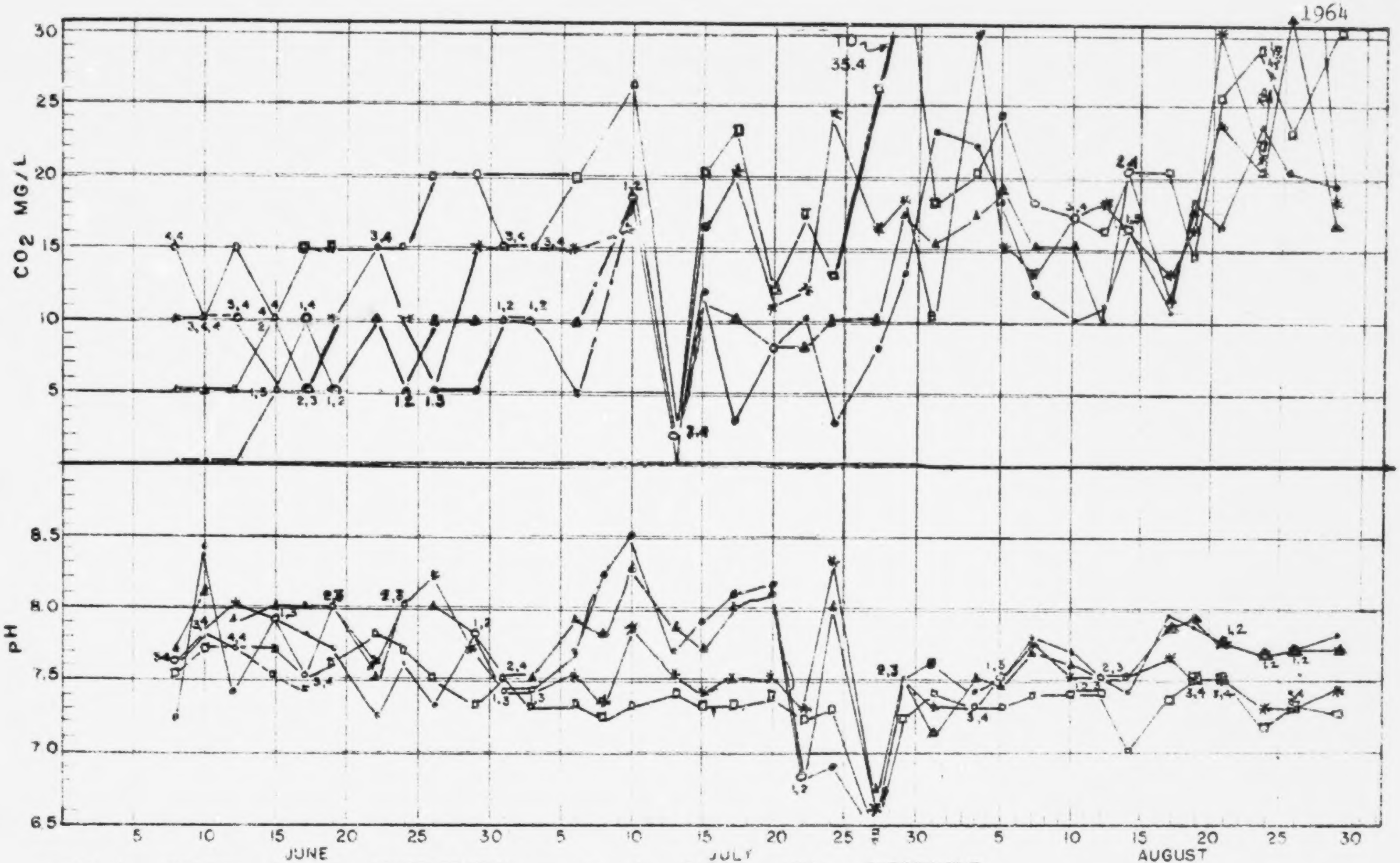


FIG. 4 CARBON DIOXIDE CONCENTRATION & pH IN MARINA AREA EXPERIMENT

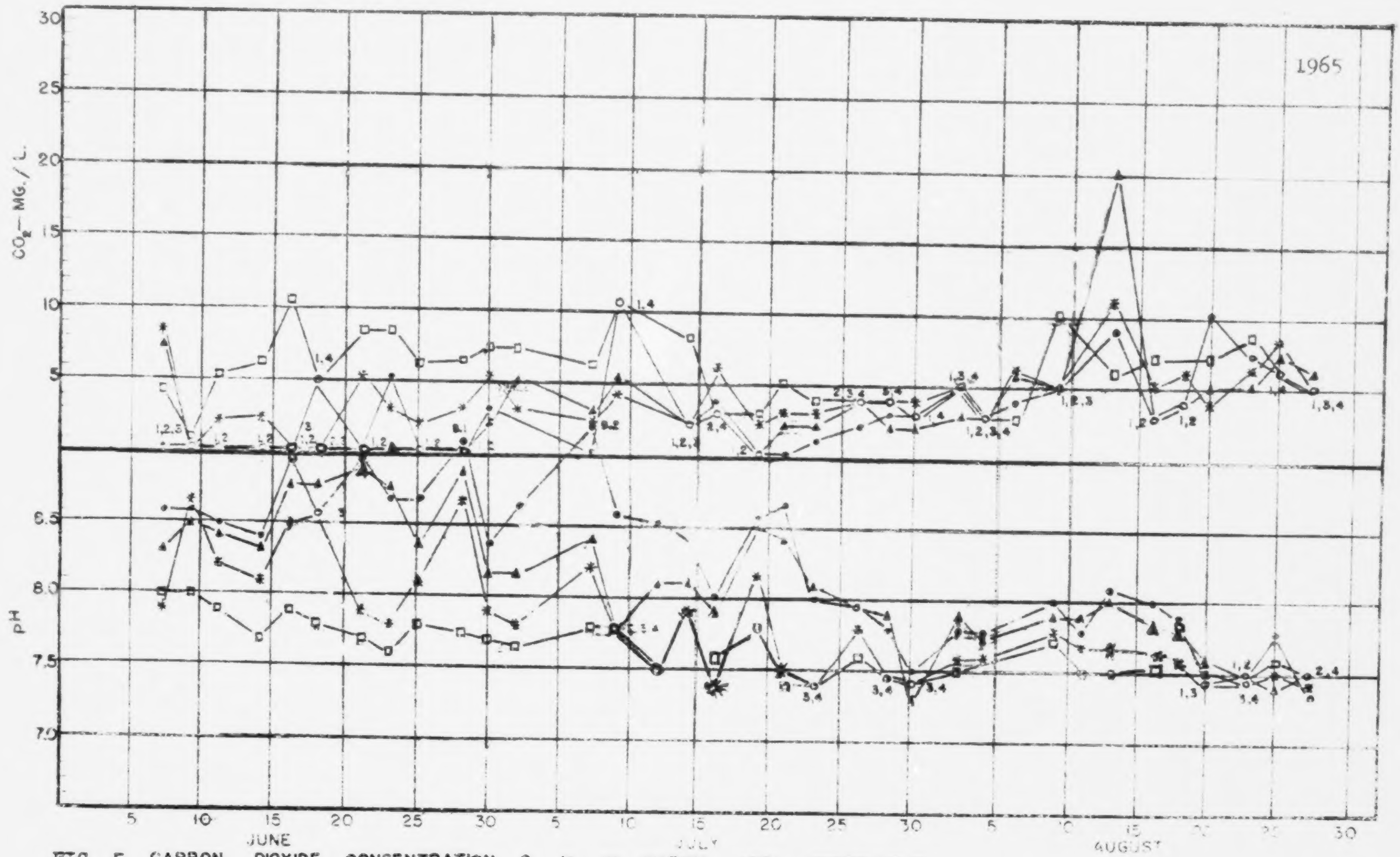


FIG. 5 CARBON DIOXIDE CONCENTRATION & pH IN MARINA AREA EXPERIMENT

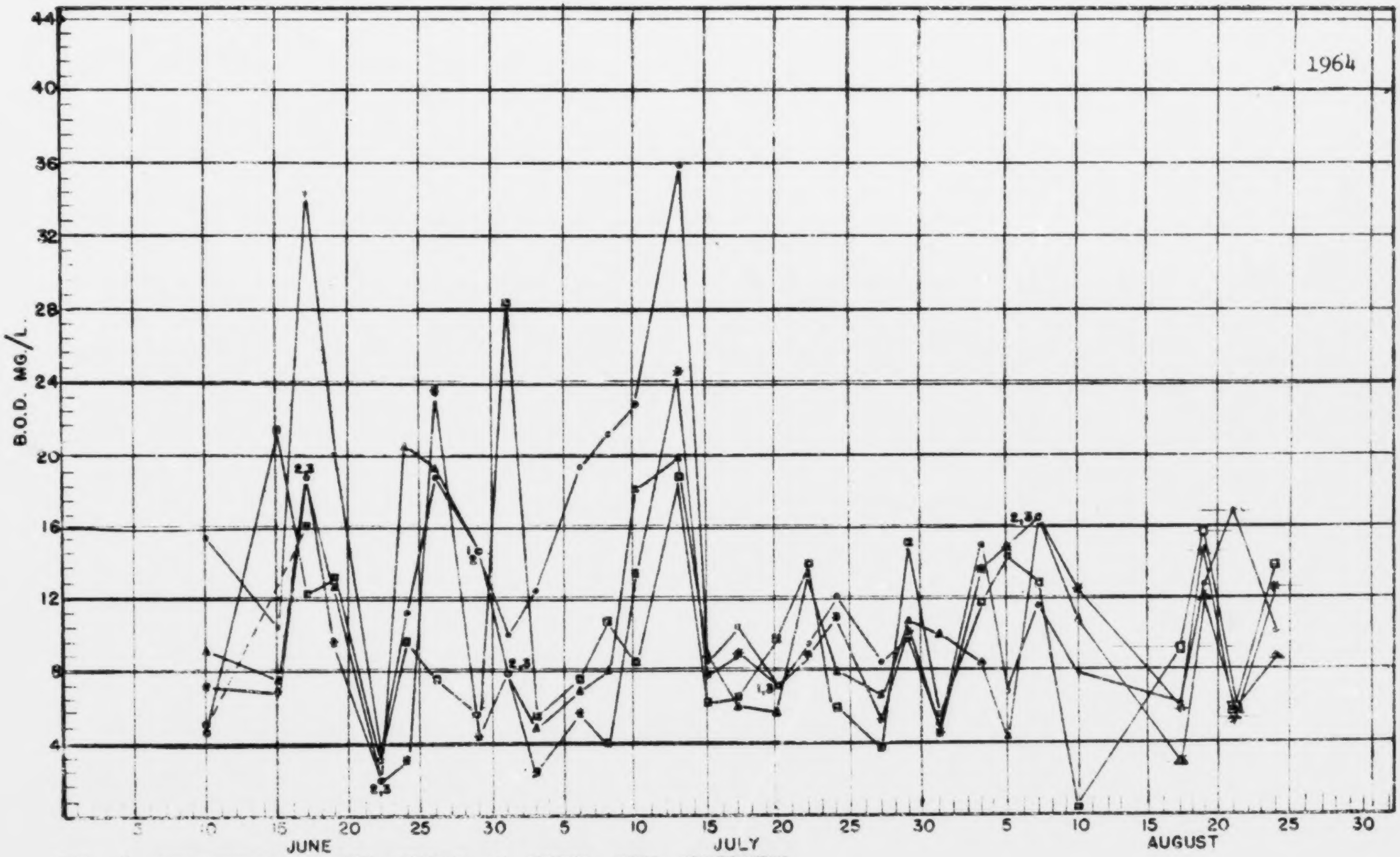


FIG. 6 BIOCHEMICAL OXYGEN DEMAND IN MARINA AREA EXPERIMENT

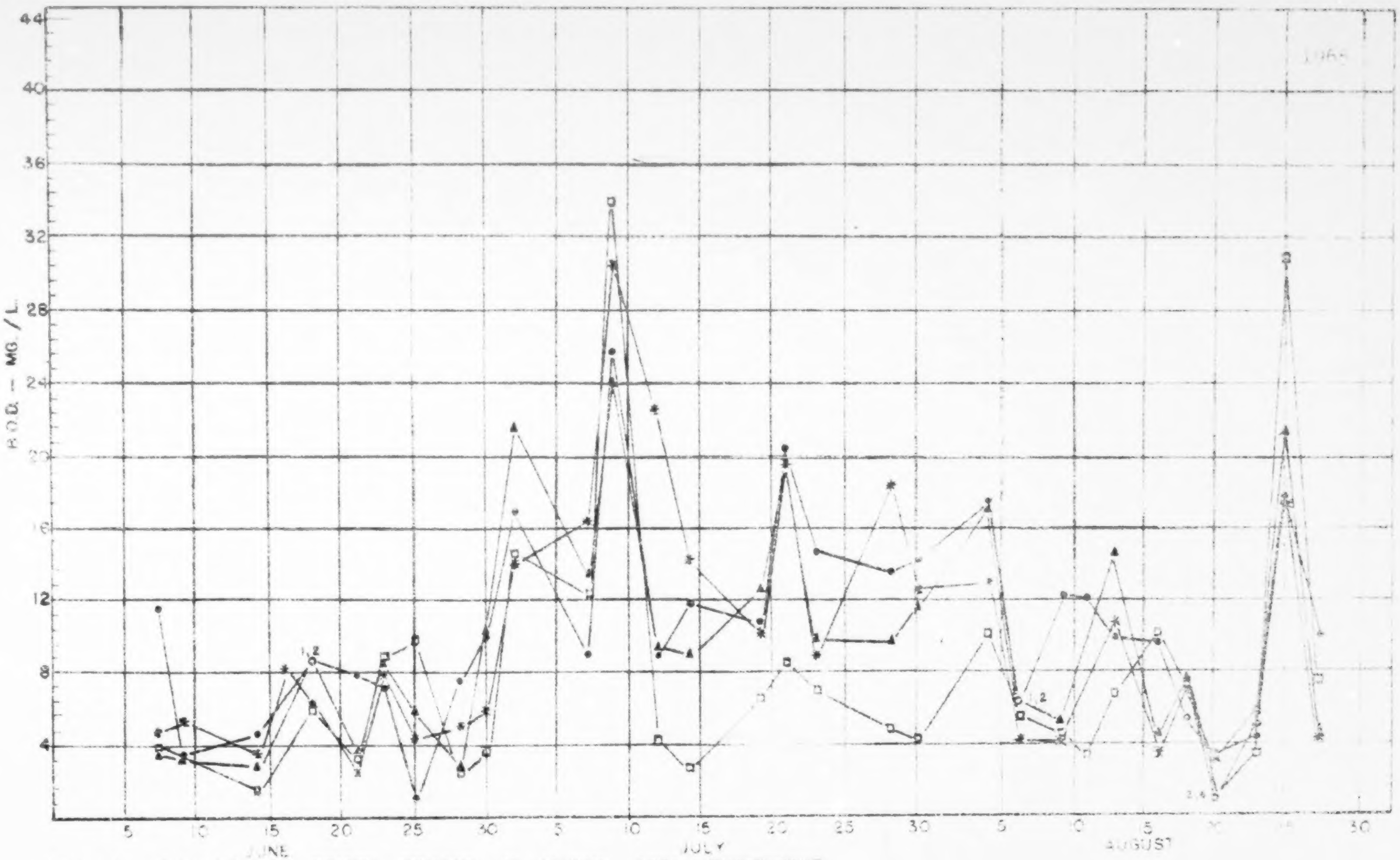


FIG. 7 BIOCHEMICAL OXYGEN DEMAND IN MARINA AREA EXPERIMENT

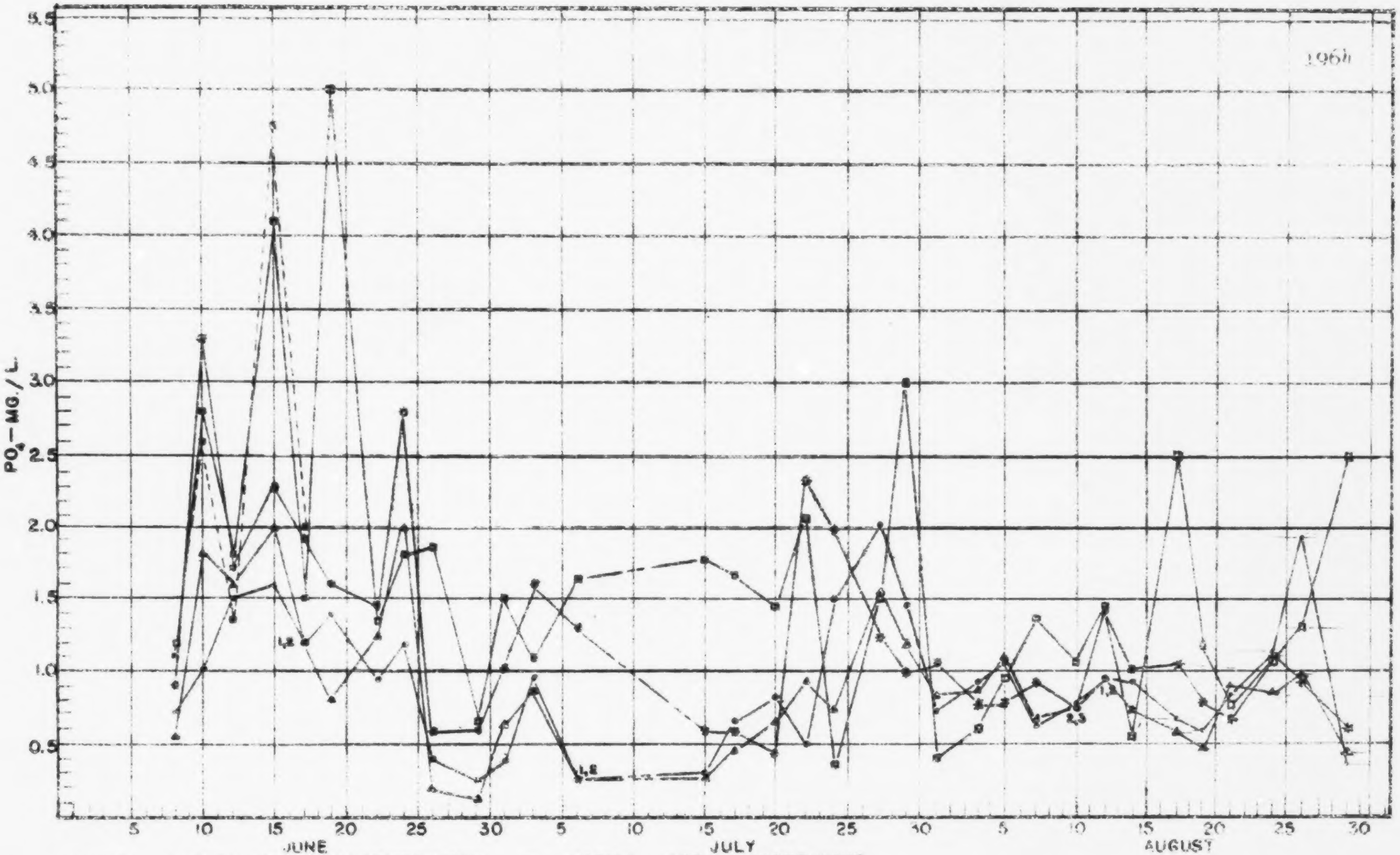


FIG. 8 PHOSPHATE CONCENTRATION IN MARINA AREA EXPERIMENT

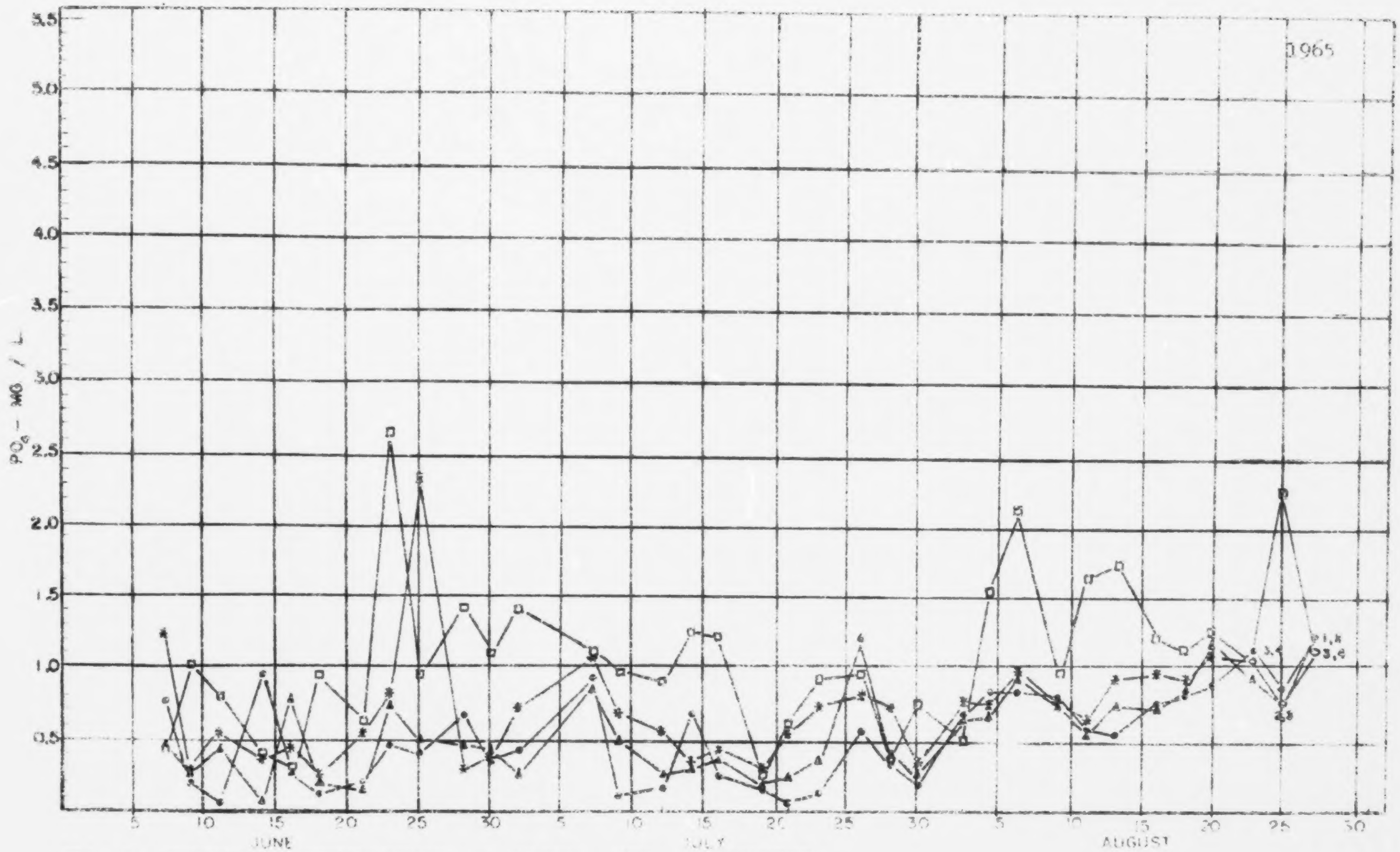


FIG. 9 PHOSPHATE CONCENTRATION IN MARINA AREA EXPERIMENT

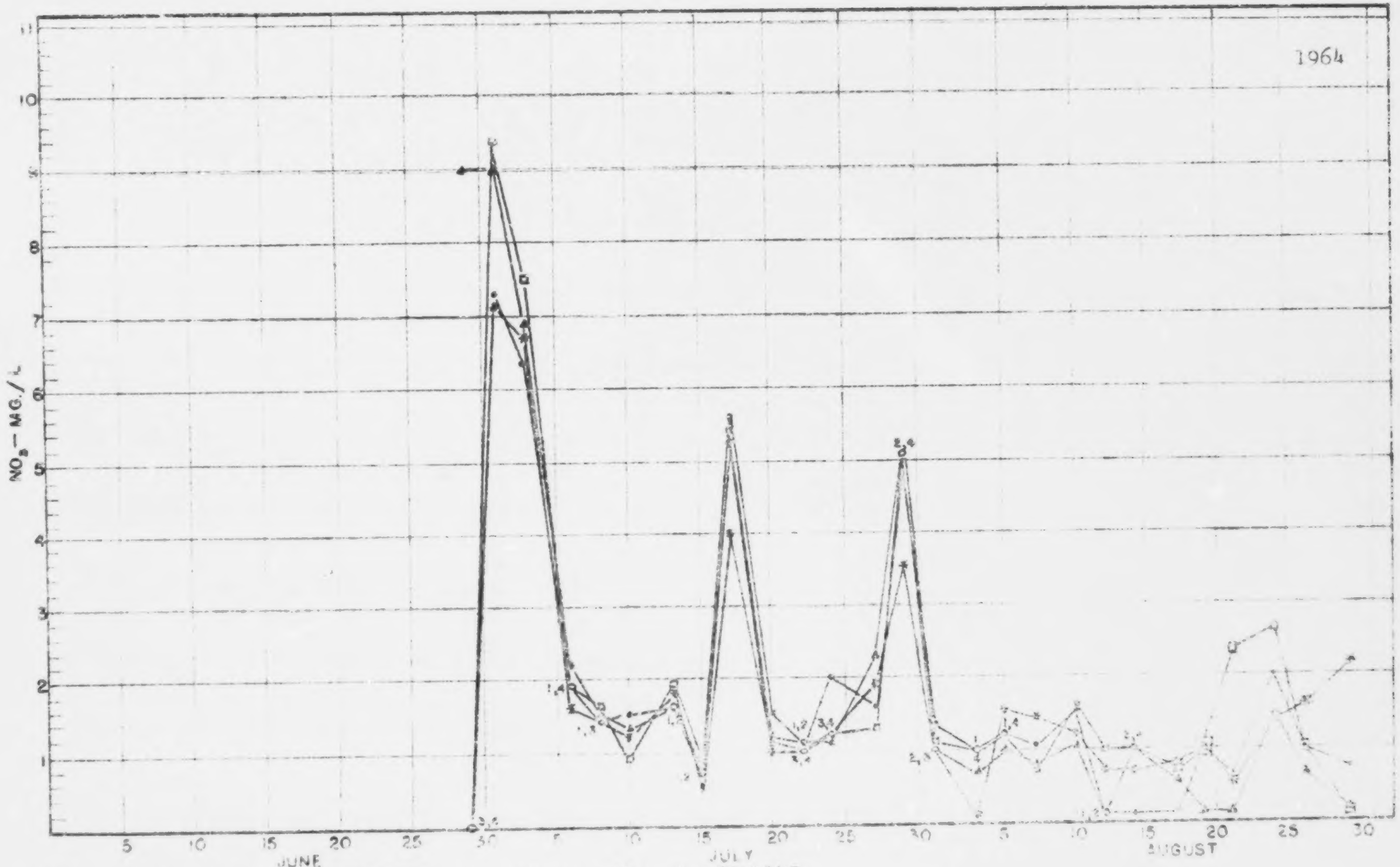


FIG. 10 NITRATE CONCENTRATION IN MARINA AREA EXPERIMENT

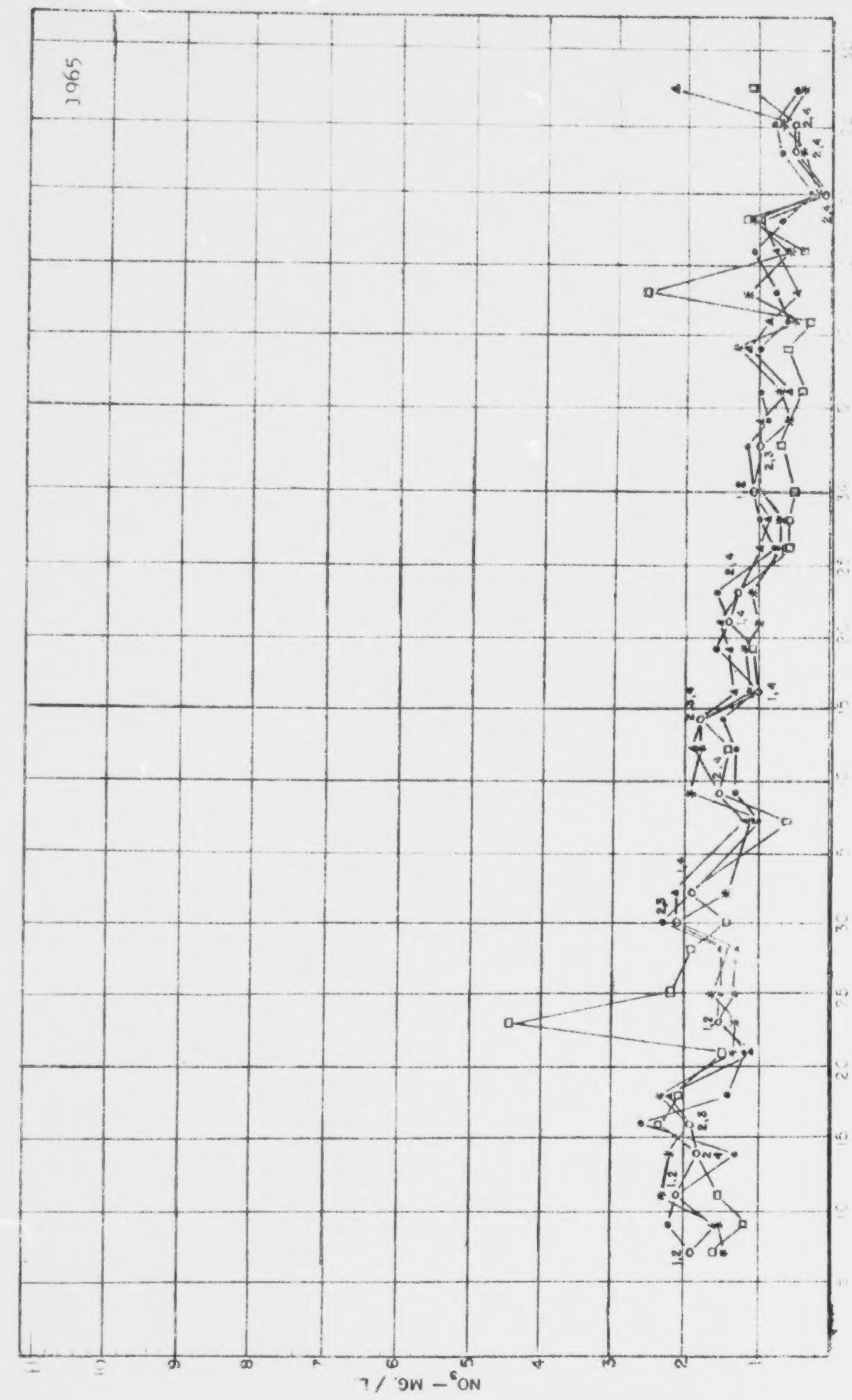


FIG. 11 NITRATE CONCENTRATION IN MARINA AREA EXPERIMENT

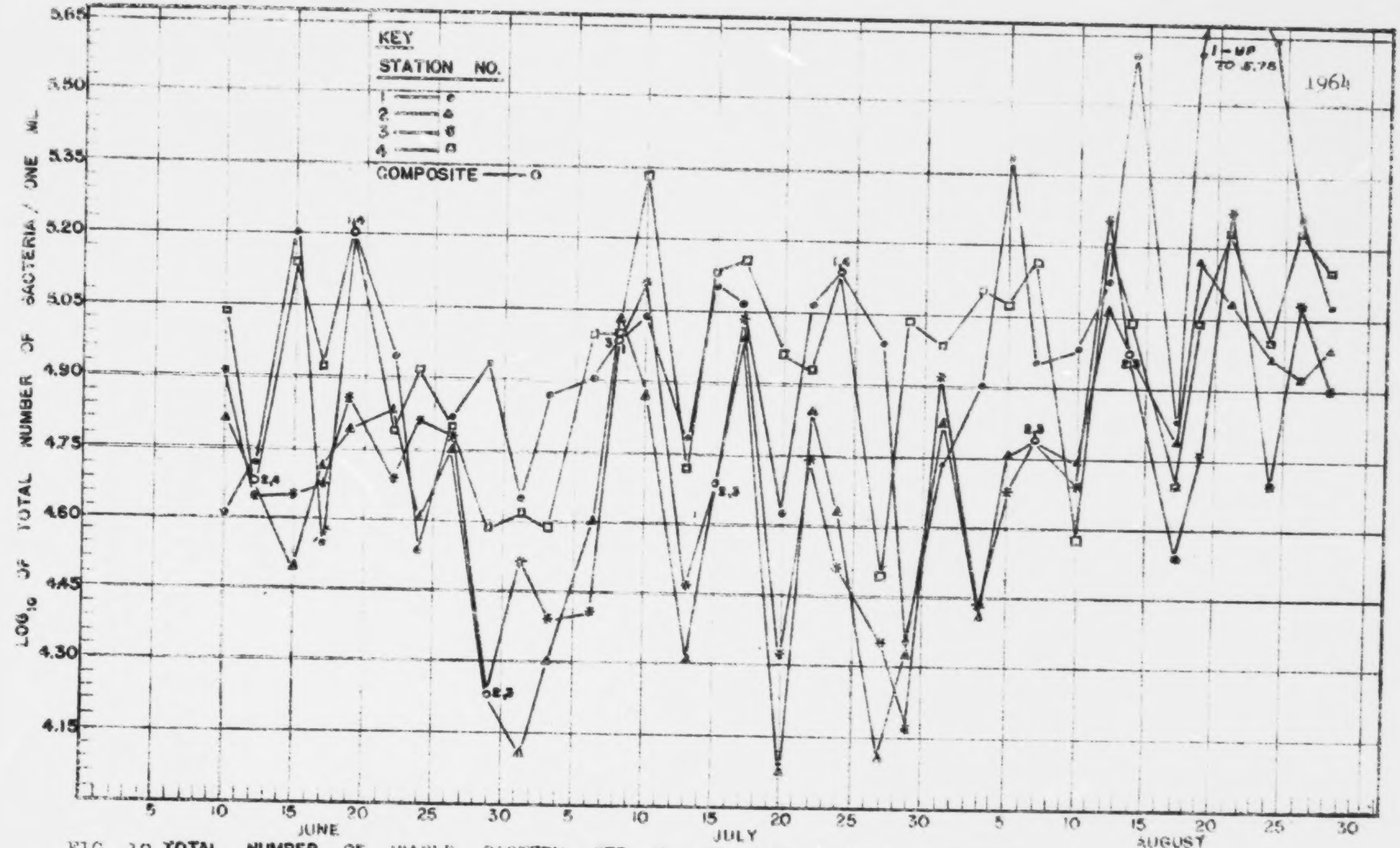


FIG. 12 TOTAL NUMBER OF VIABLE BACTERIA PER ML IN MARINA AREA EXPERIMENT

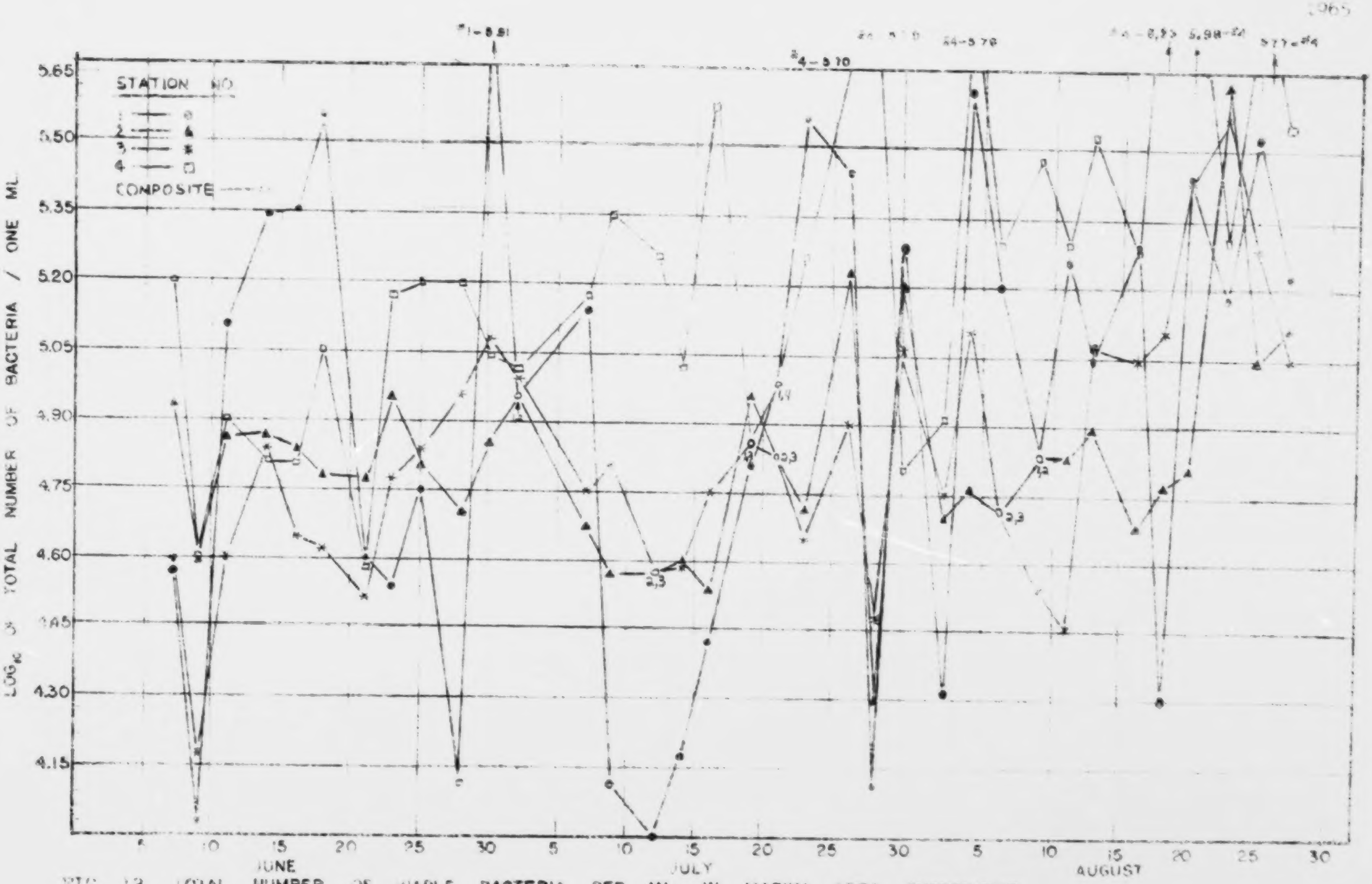
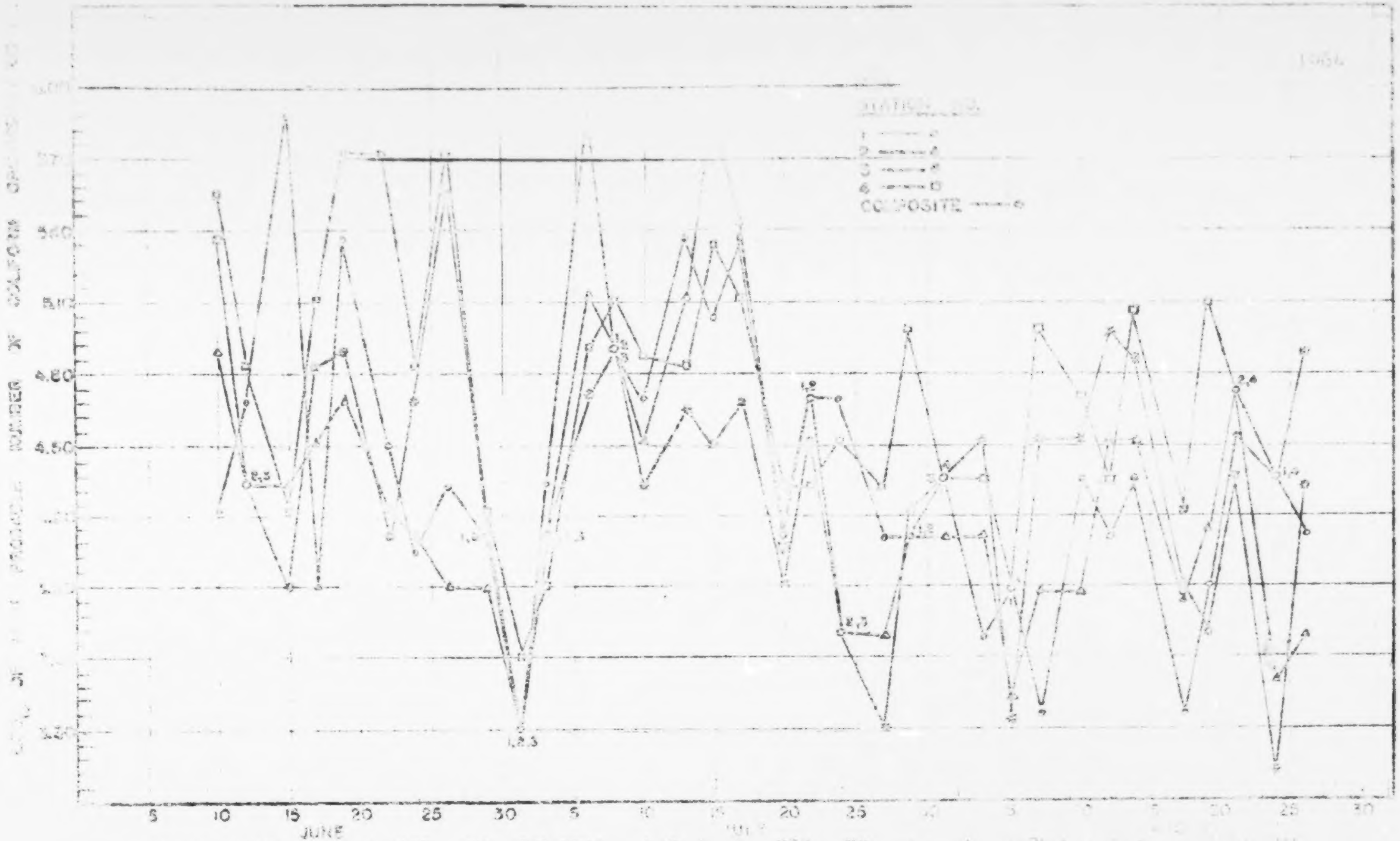


FIG. 13 TOTAL NUMBER OF VIABLE BACTERIA PER ML IN MARINA AREA EXPERIMENT



[illegible] 14 MOST PROBABLE NUMBER OF COLIFORM [illegible] PER 100 [illegible]

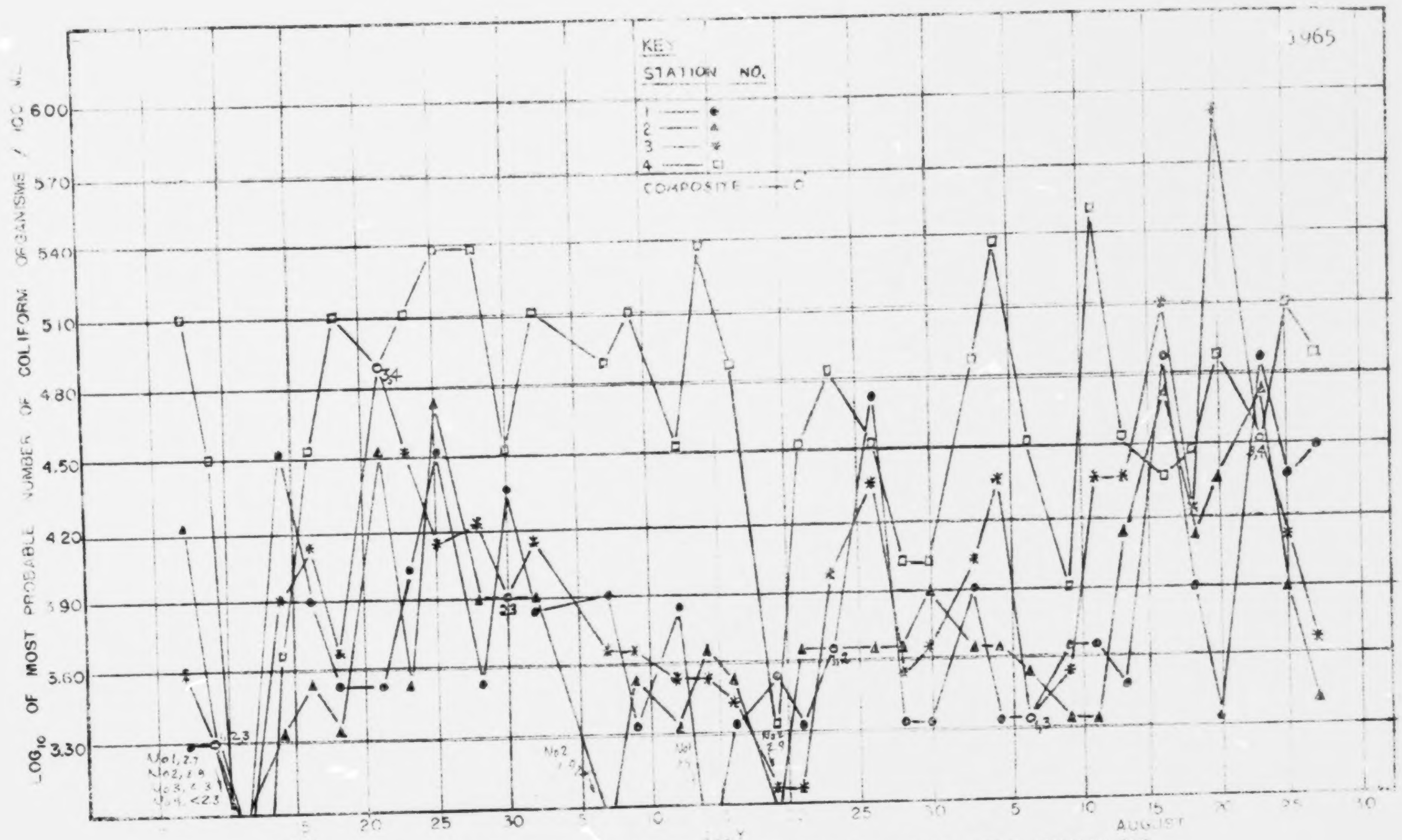


FIG. 15 MOST PROBABLE NUMBER OF COLIFORM ORGANISMS PER 100 ML. IN MARINA AREA EXPERIMENT

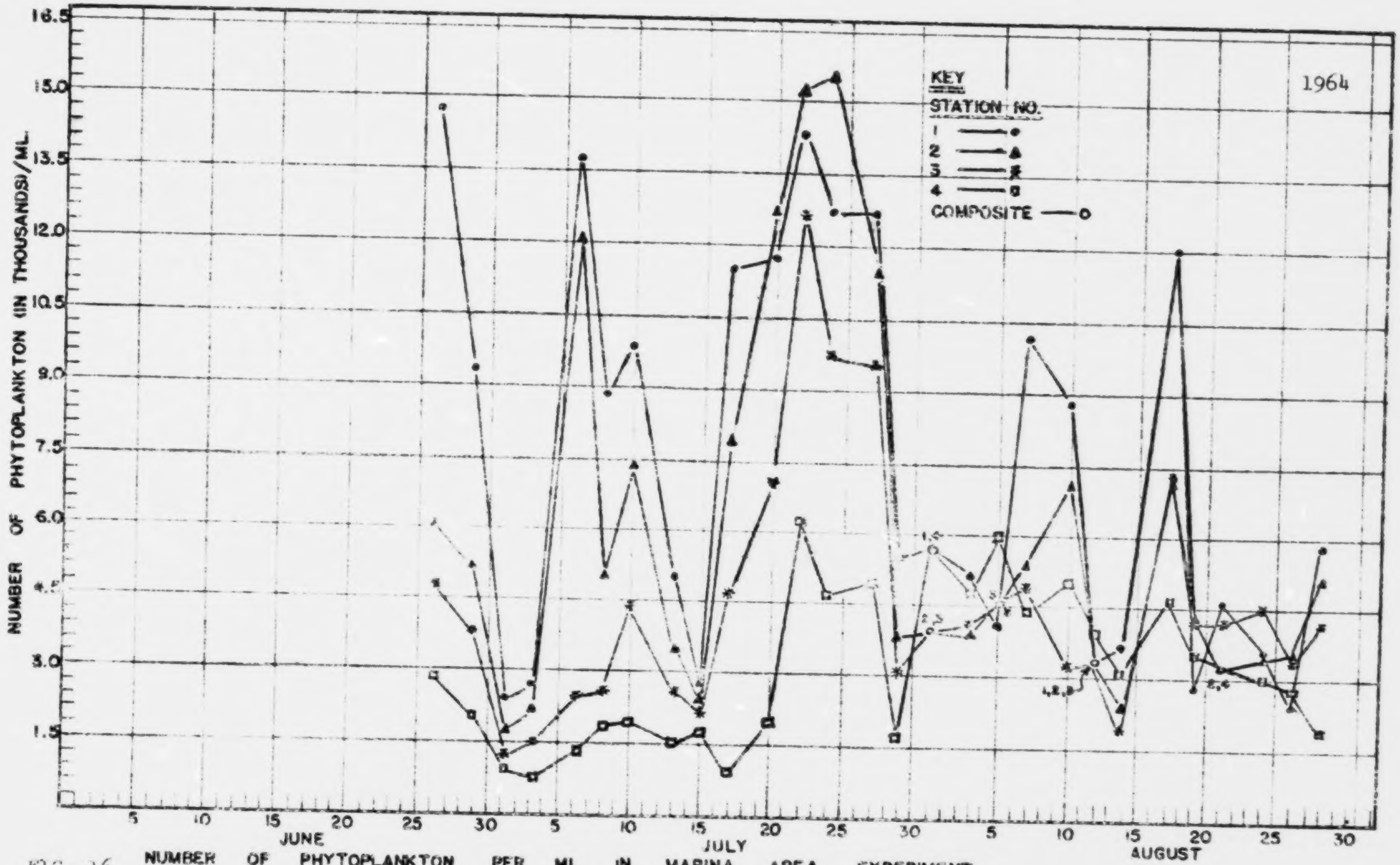


FIG. 16 NUMBER OF PHYTOPLANKTON PER ML. IN MARINA AREA EXPERIMENT

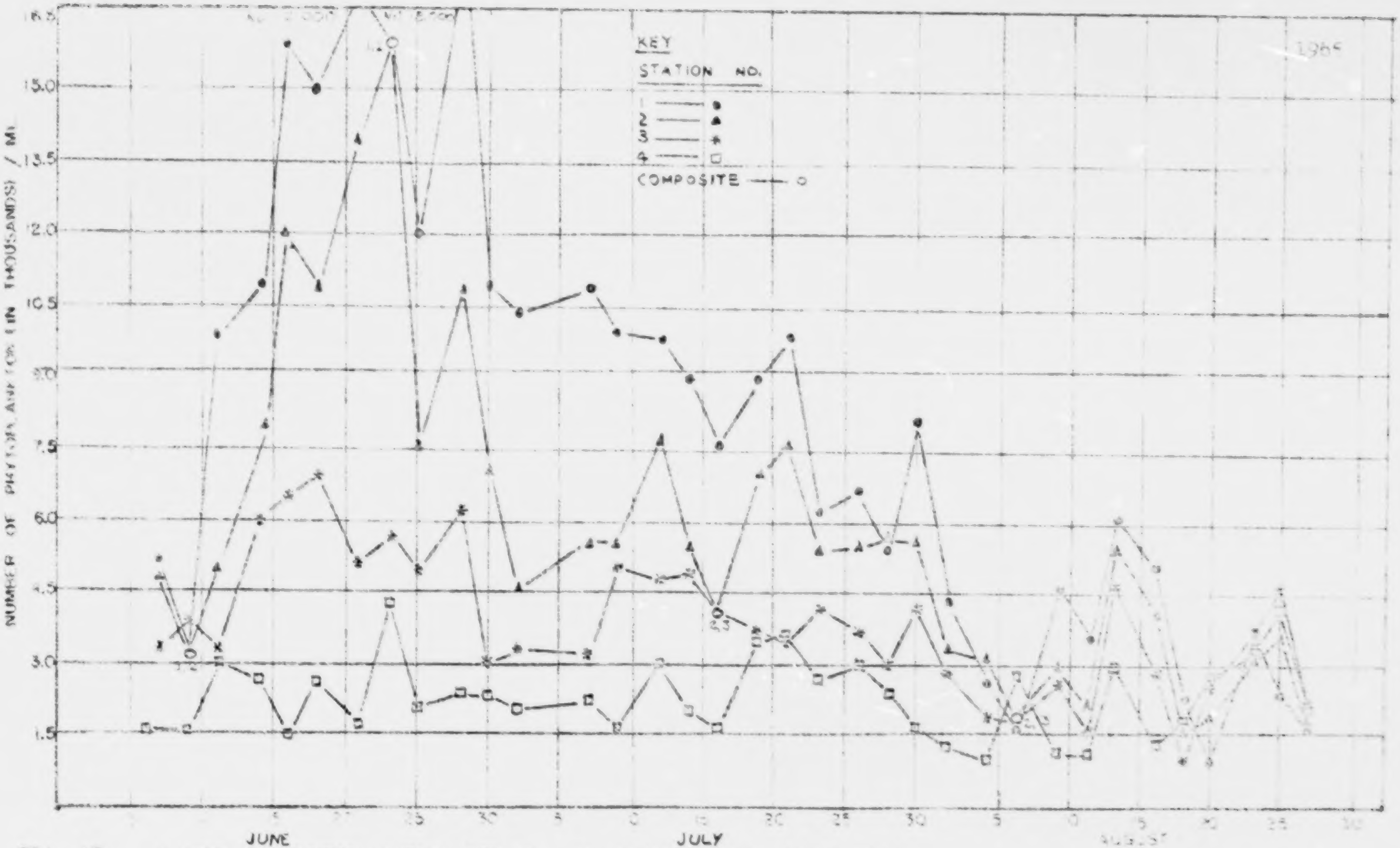


FIG. 17 NUMBER OF PHYTOPLANKTON PER ML. IN MARINA AREA EXPERIMENT

1965

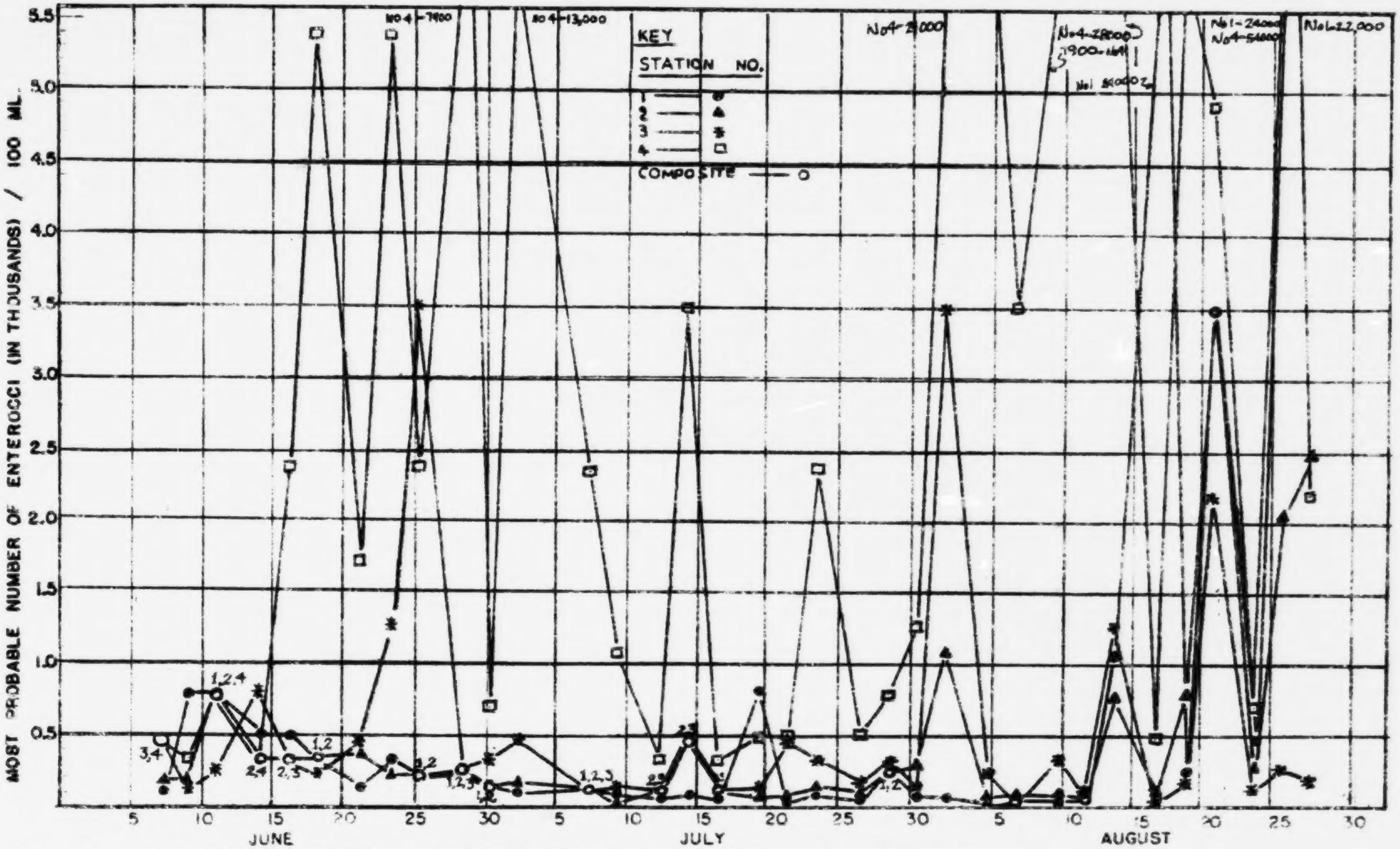


FIG. 18 MOST PROBABLE NUMBER OF ENTEROCCI PER 100 ML. IN MARINA AREA EXPERIMENT

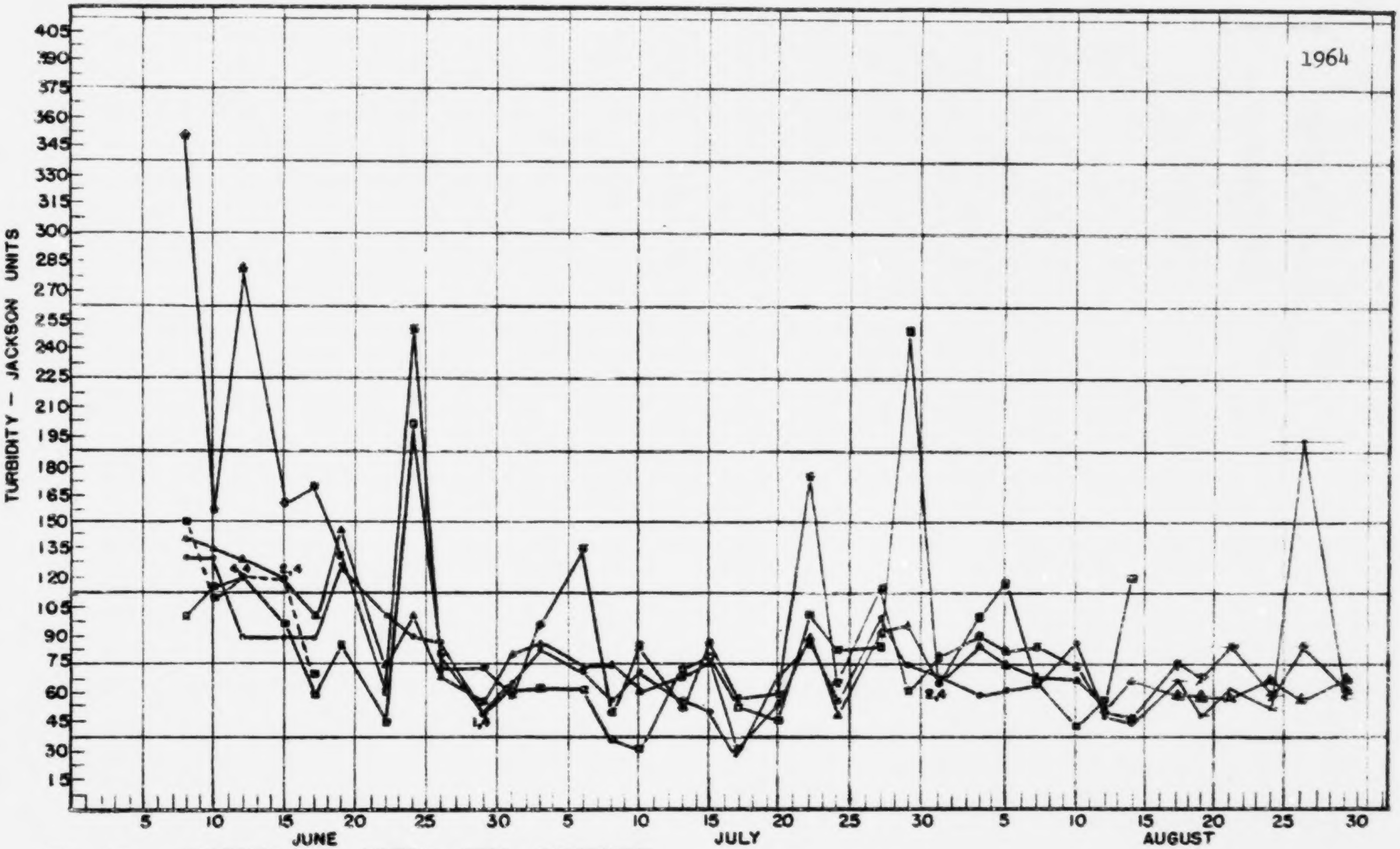


FIG. 19 TURBIDITY IN MARINA AREA EXPERIMENT

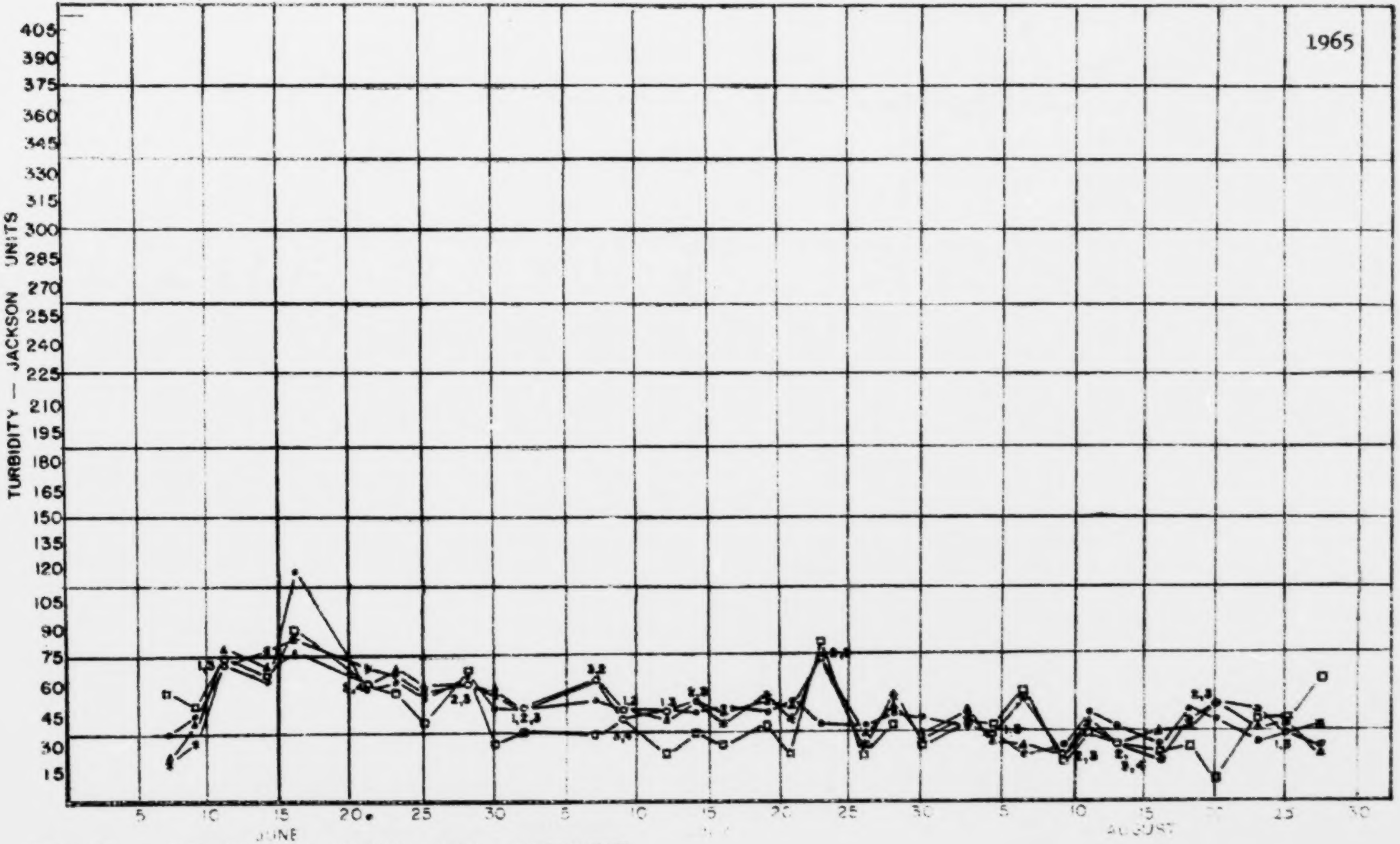


FIG. 20 TURBIDITY IN MARINA AREA EXPERIMENT

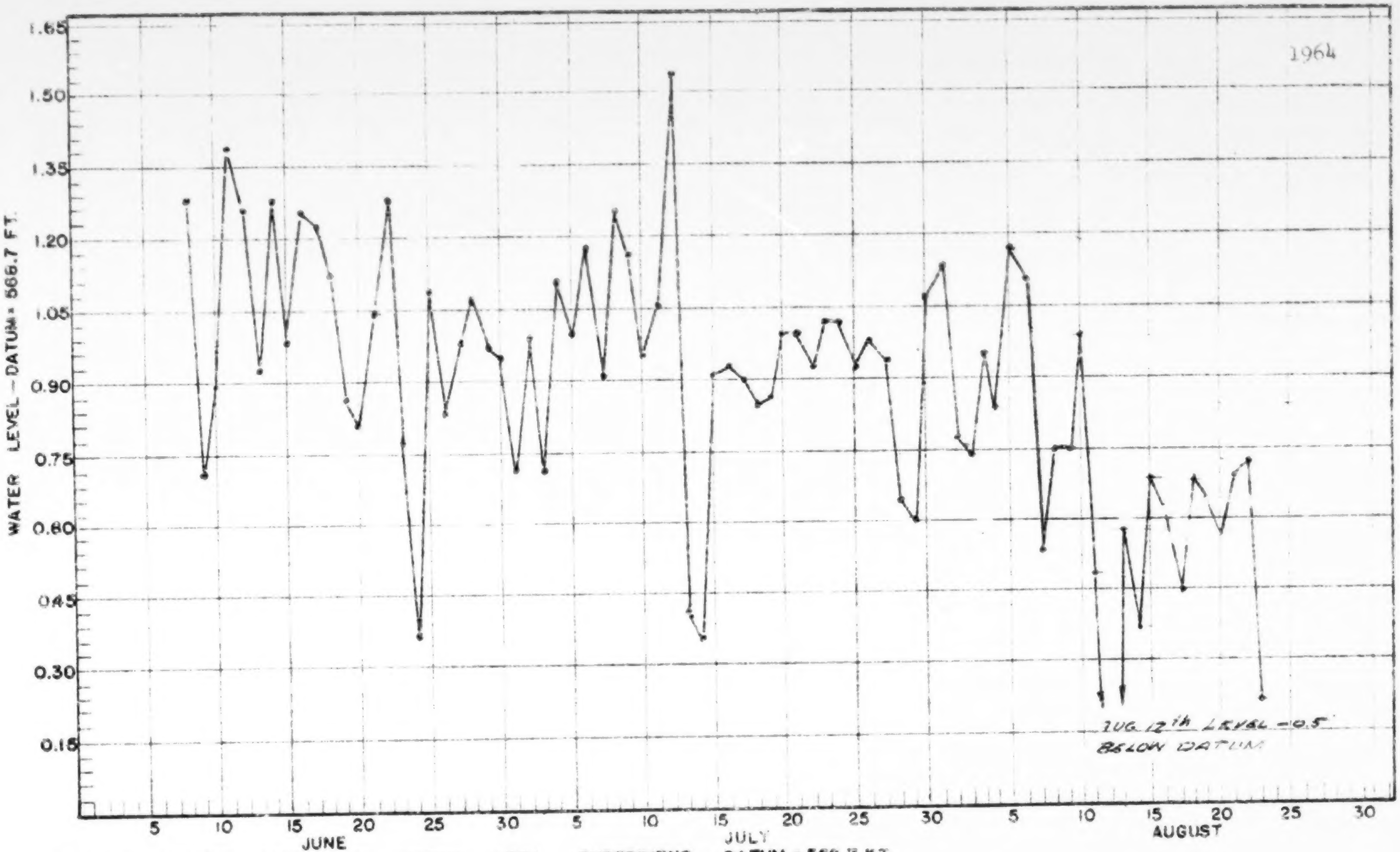


FIG. 21 WATER LEVEL IN MARINA AREA EXPERIMENT – DATUM = 568.7 FT.

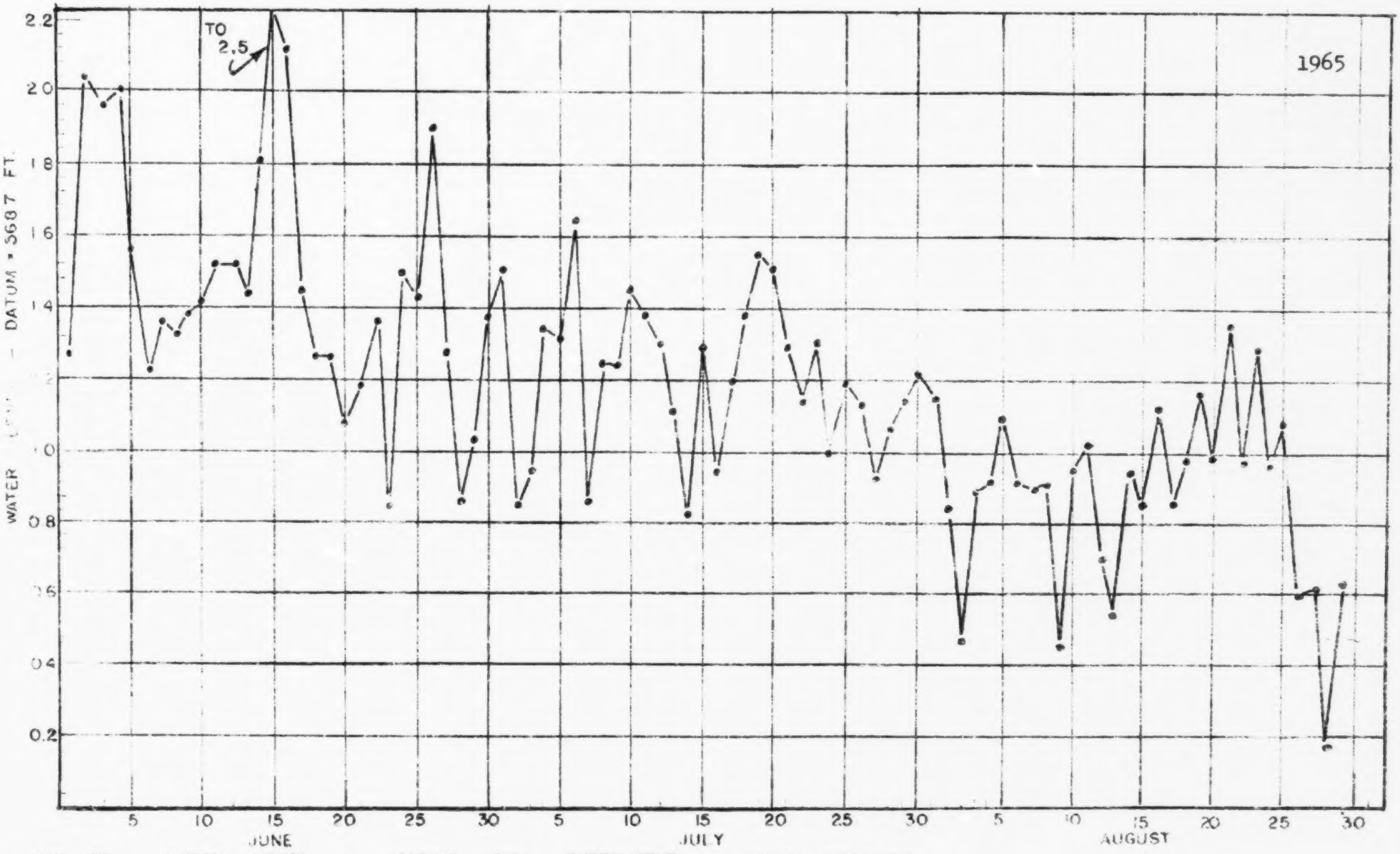


FIG. 22 WATER LEVEL IN MARINA AREA EXPERIMENT -- DATUM = 568.7 FT.

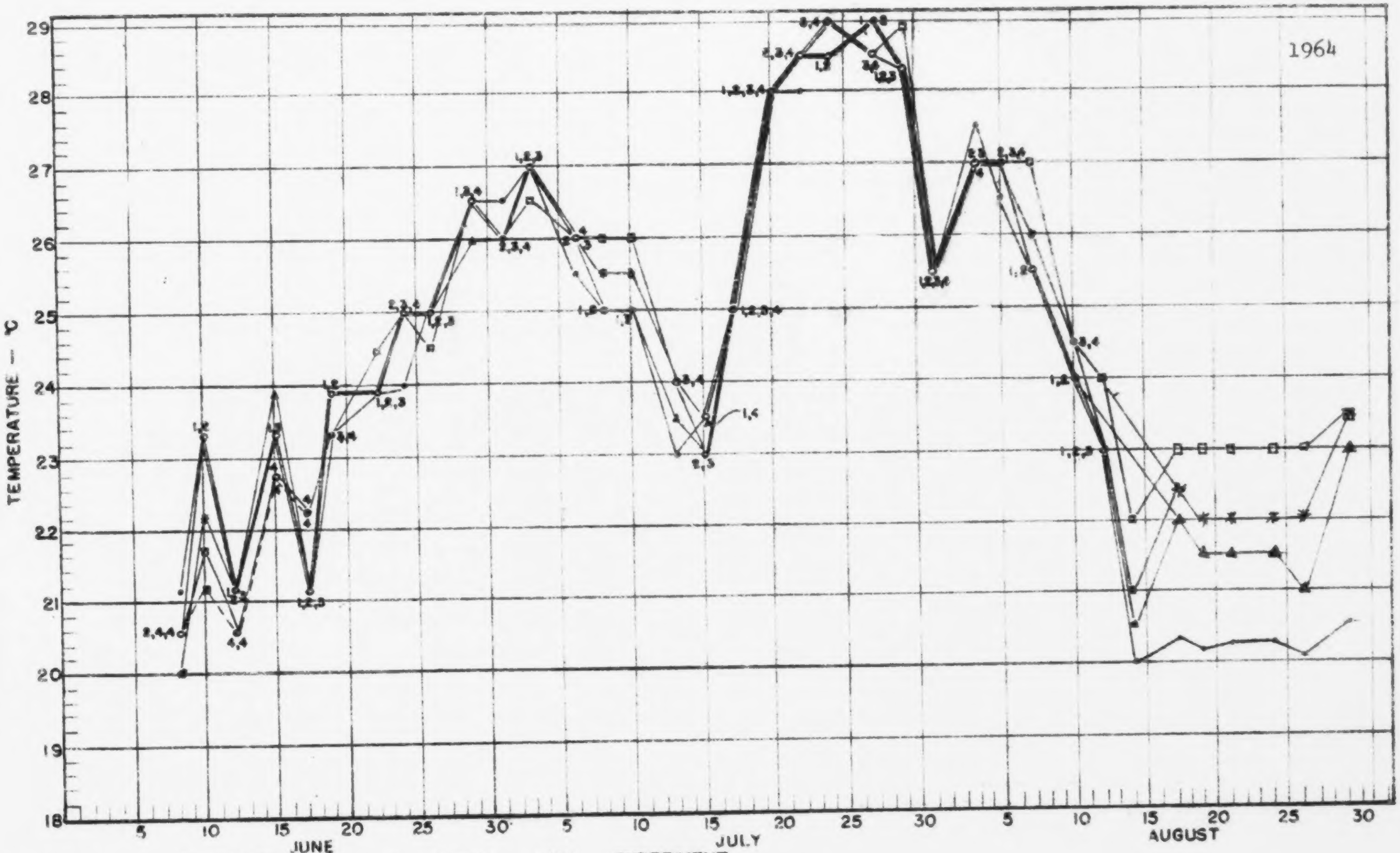


FIG. 23 °C TEMPERATURE IN MARINA AREA EXPERIMENT

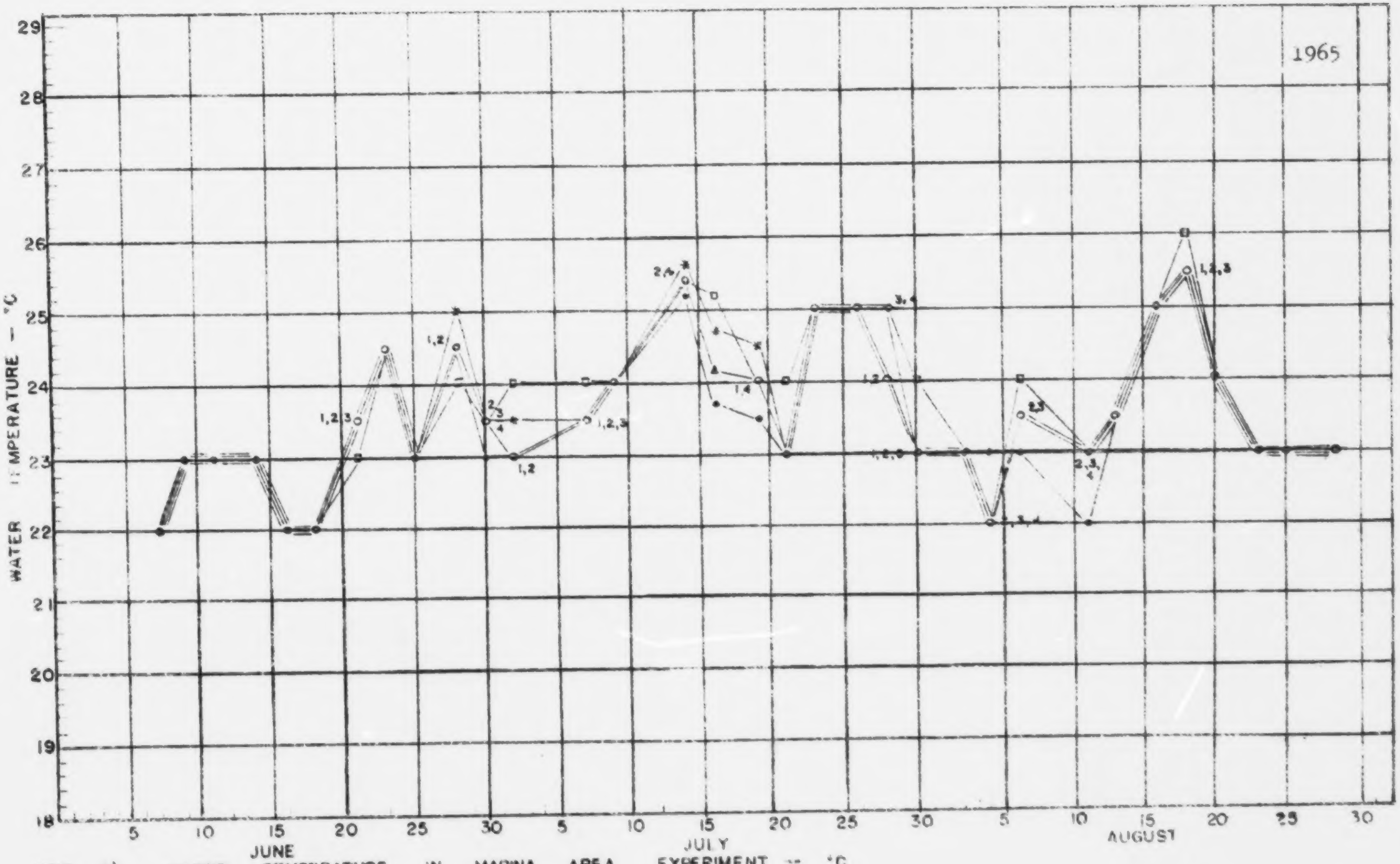


FIG. 24 WATER TEMPERATURE IN MARINA AREA EXPERIMENT -- °C

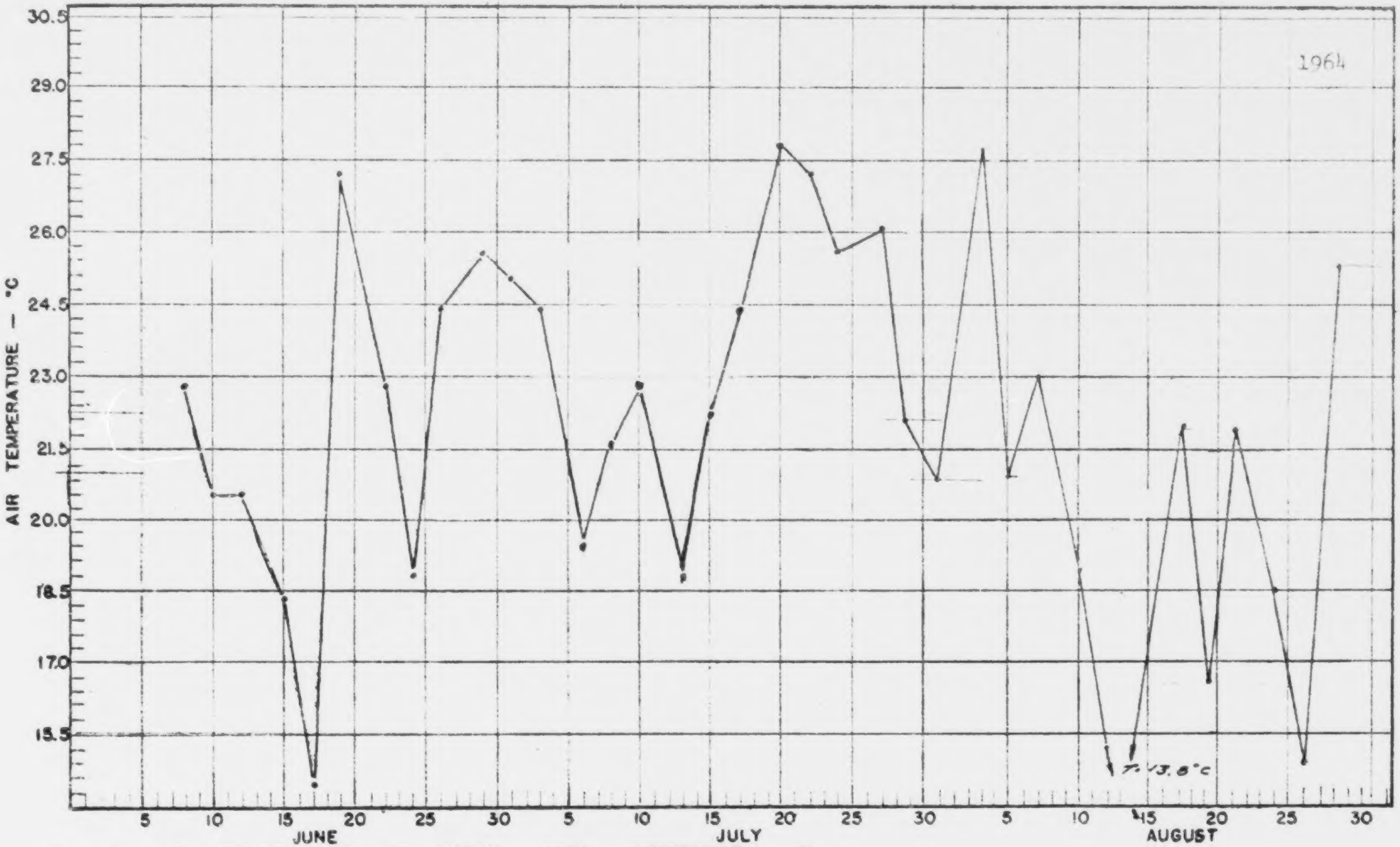


FIG. 25 AIR TEMPERATURE IN MARINA AREA EXPERIMENT — °C

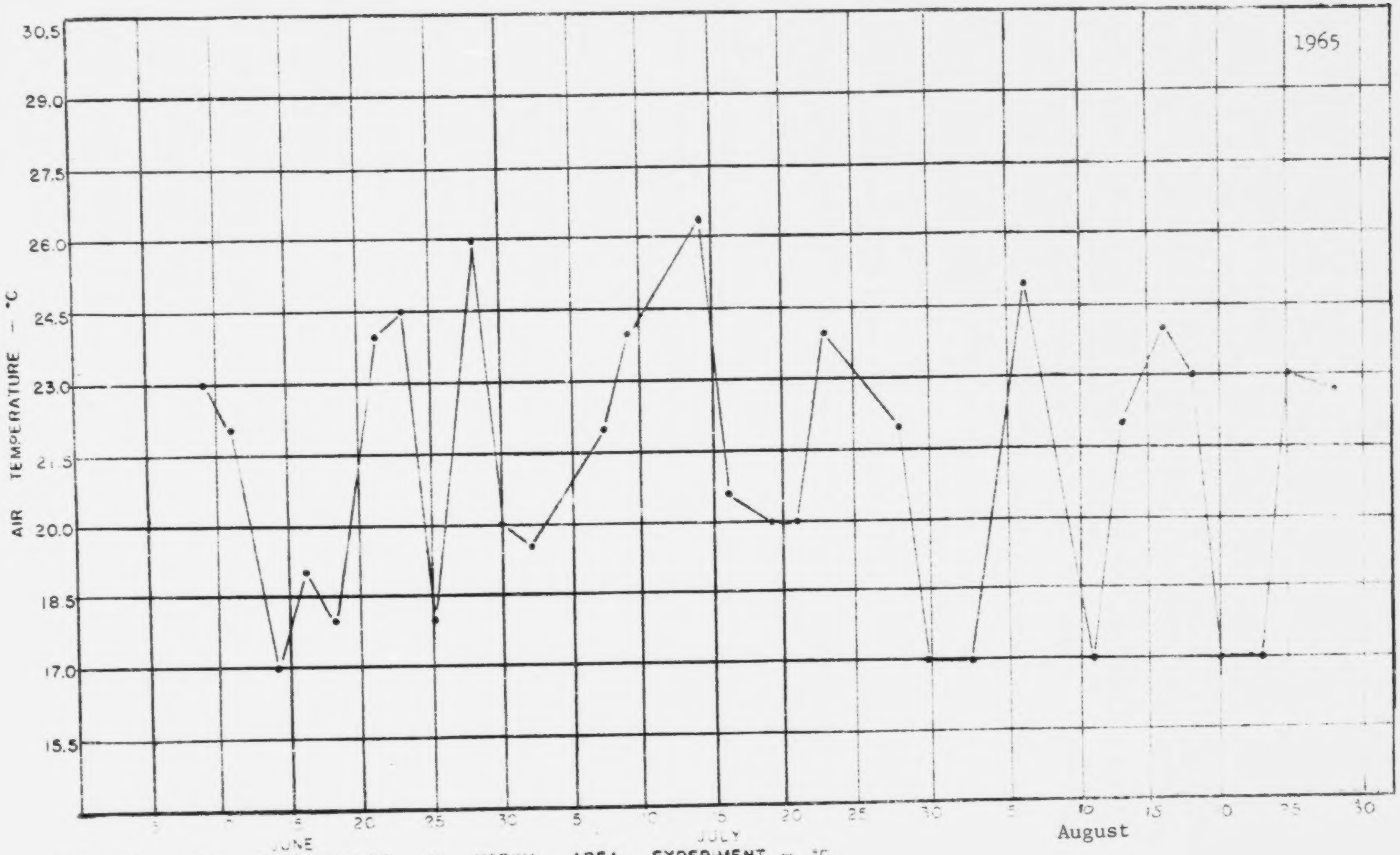


FIG. 26 AIR TEMPERATURE IN MARINA AREA EXPERIMENT — °C

MARINA DISCUSSION

Observations of graphs for the four stations in the basin area in 1964 show definitive characteristics. Clearly the oxygen levels at stations one and two are higher than at station three and much higher than at station four. Supersaturation of dissolved oxygen occurs at various times during the observation period. During 1965 the levels remained nearer saturation levels. It is assumed that bubble diffusion decreased the surface tension during the aeration period.

Observations show that aeration of the lower half of the marina in 1965 proved to be beneficial. (See Figure 1 for hose alignment) Dissolved oxygen content at Stations 1 and 2 were always higher than at Stations 3 and 4 which were unaerated. A tendency toward oxygen depletion took place throughout the period of study. Water temperature rose between June and September which could have accounted for some of the drop in dissolved oxygen. Dredging of the lagoon in 1965 could also have contributed to the depletion of dissolved oxygen.

There was a distinct change in the aquatic life from June through August. In June, large schools of "pin head" minnows appeared in the aerated portion of the lagoon. In July, larger minnows were seen in the same vicinity. Toward the end of August, the aerated portion of the marina was inhabited by an exceedingly large number of fish of all sizes and species. Unfortunately, with the existing equipment it was impossible to increase the air supply, and the oxygen content dropped to its lowest level of the season. (See Figure 3 Date: August 23, 1965) At the same time, the biological oxygen demand rose rapidly as can be seen in Figure 7.

It is impossible to say that the fish invasion of the aerated portion of the marina was due solely to the higher dissolved oxygen content. Various biologists and limnologists were consulted about such an occurrence. Those questioned stated that it would be natural for fish to seek areas of higher dissolved oxygen where better feeding grounds exist. A change in current patterns and water temperature may have contributed to this phenomenon. Further studies by limnologists would be needed to clarify this type of aquatic activity.

With but one exception, the dissolved oxygen content remained higher at Stations 1 and 2 throughout the period of study. Constant aeration suppli-d on a twenty-four hour basis helped reduce the problem of oxygen uptake by algae during periods of darkness. Laboratory studies have shown that continuous aeration increased algal growth rates. Increased algal growth rates increased nutrient "stripping", although nutrient "stripping" was not as evident in the marina studies. However, at no time was the water surface covered with floating masses of aquatic growth as had been observed in past years. It may well be that on a long term basis greater improvement of water quality would occur. Because of the close proximity of the Maumee River where insanitary conditions prevail, it was found difficult to obtain reduction of pollutants in this particular marina.

Nitrate and phosphate content fluctuated very little during the summer of 1965 as compared to the same unaerated period of 19654. Increased phosphate content along with decreased nitrate content and a marked dissolved oxygen decrease during the month of August would indicate the probability of severe pollution existing in the Maumee River.

Prior to the middle of August, hydrogen ion concentrations and carbon dioxide content indicated favorable conditions for aquatic growth. After the second week in August, the carbon dioxide content increased while there was a drop in the pH. .(See Figures 4 and 5)

Biological measurements which were considered most important were incorporated in the study. Previous measurements, both in the laboratory and the marina, indicated that phytoplankton would be one of the necessary parameters. In terms of the physical characteristics of the marina, determinations of coliform density was considered to be another important parameter. Enterococci densities were measured for comparison with coliform densities.

The situation with respect to the distribution of phytoplankton was the reverse of that observed for bacteria. On 28 of 35 days that samples from the river (Station No. 4) had the lowest number of phytoplankton. These figures are recorded in Figures 16 and 17.

The situation with respect to the most probable number of enterococci was quite similar. On 28 of 35 sampling dates the highest numbers were observed at the river station. On 25 of 35 occasions the lowest numbers were observed in either Stations No. 1 and No. 2. (See Figure 18 and for averages, Table XX)

Increased rainfall along with increased runoff during 1965 resulted in higher water levels in the marina. It is assumed that this affected the turbidity readings as compared to the unaerated period of 1964. It is also possible that dredging operations during 1965 could have had some effect on the turbidity measurements. Aeration of the marina in 1965 cannot be discounted as a factor in the reduction of turbidity. Laboratory studies have shown that continuous bubble diffusion created vertical current patterns resulting in lower turbidity. Therefore, it would be difficult to make a comparison of turbidity measurements of 1964 and 1965 because of the different conditions which existed during the two periods of study.

The cost of operating and maintaining the aeration system wad determined. Operation at ten pounds pressure resulted in a twelve hour operating period. Each compressor was run by a one half horse power General Electric motor from a 115 volt line. Allowing for the fact that this type compressor unit was not designed specifically for this type of duty, a fifty per cent efficiency was assumed. The price per kilowatt hour was increased from two and one half cents to three cents to provide an additional margin for operational cost. On this basis, the cost per unit compressor with twelve hundred feet of hose was approximately twenty-five to thirty cents per day or forty eight dollars per month to operate all compressor units.

SECTION III

STATISTICAL ANALYSIS

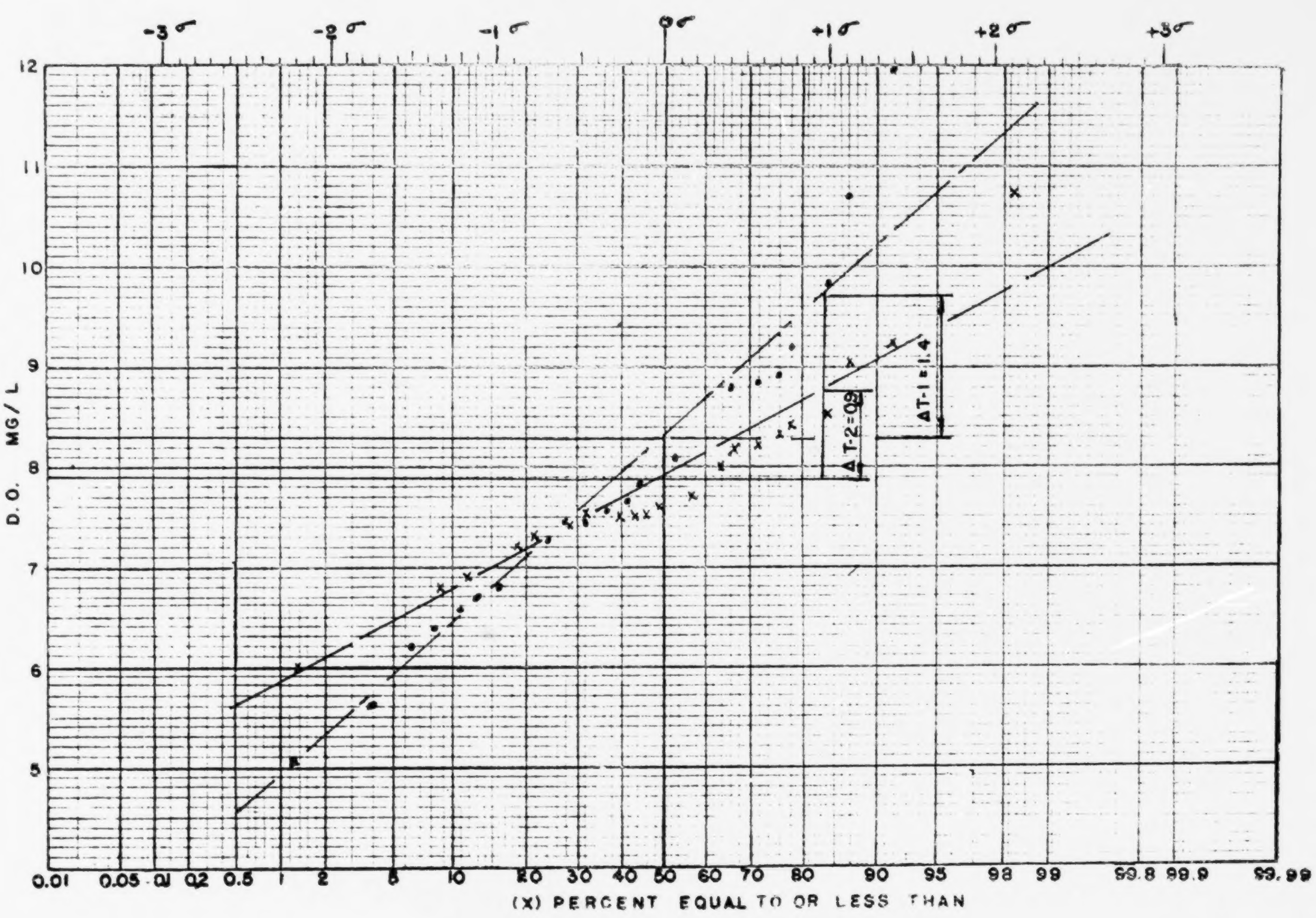


Fig. 1-A Probability diagram of dissolved oxygen concentration in tanks No. 1 and No. 2

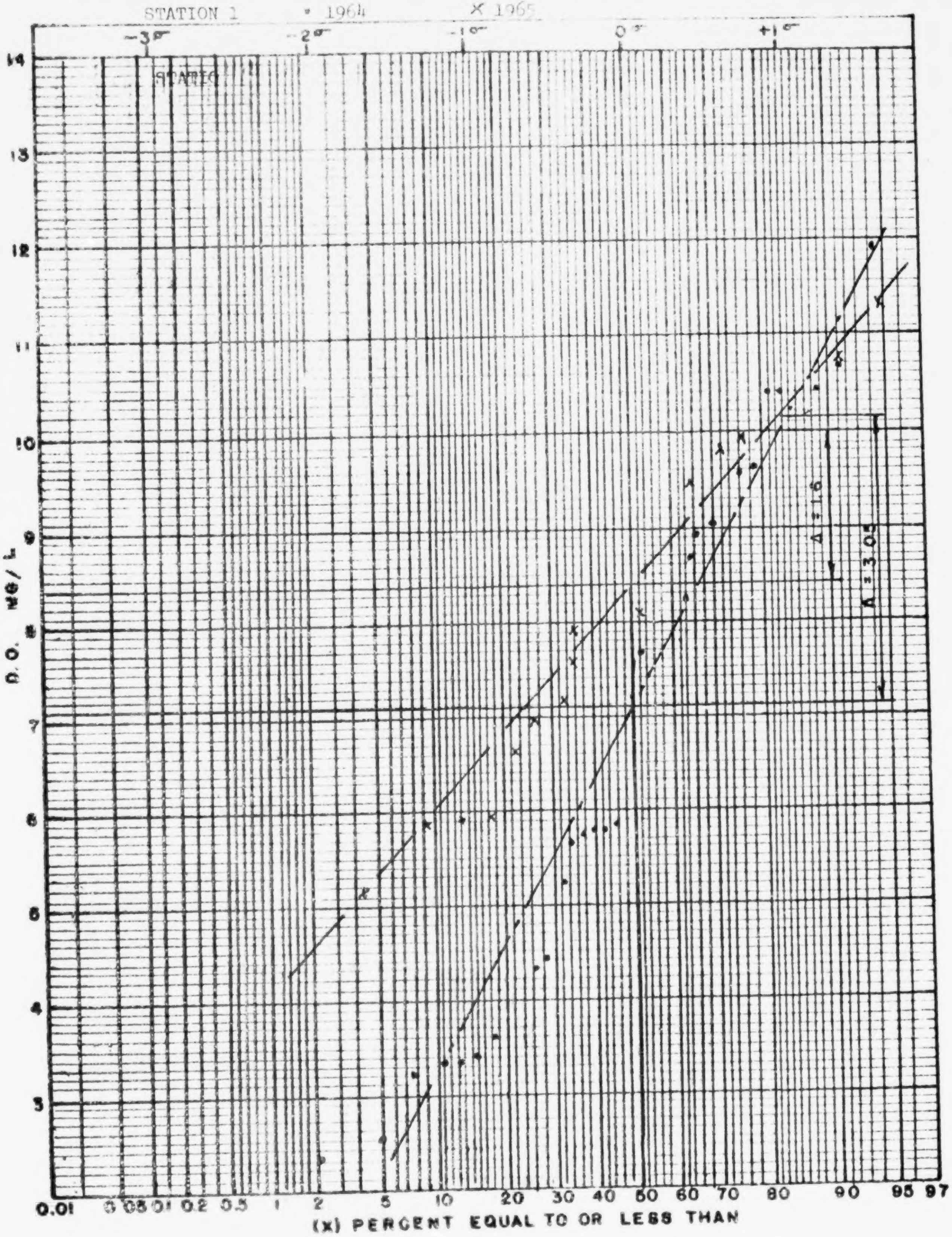


FIG. 1 Probability diagram of dissolved oxygen concentration at Station 1

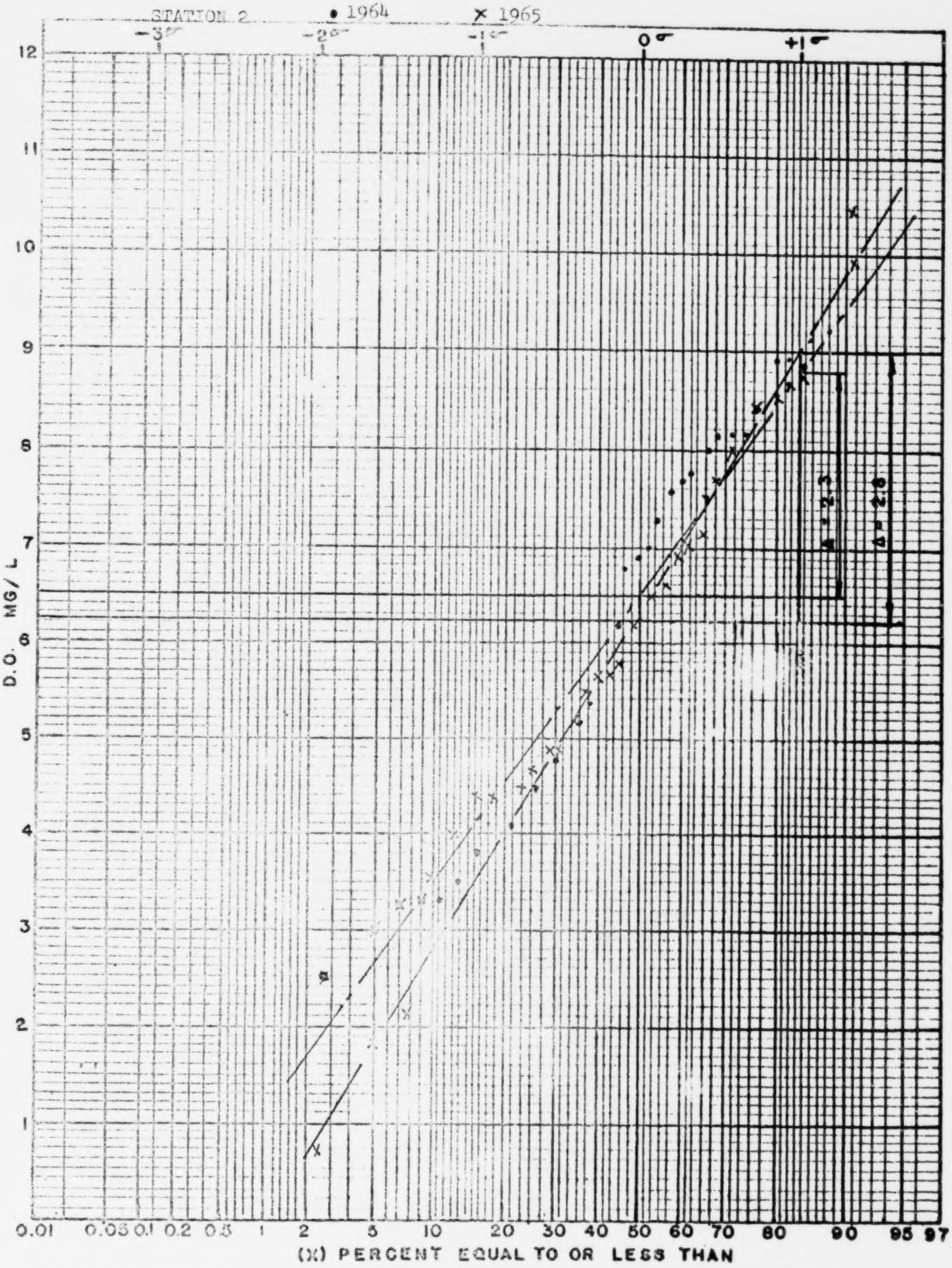


FIG. 2 Probability diagram of dissolved oxygen concentration at Station 2

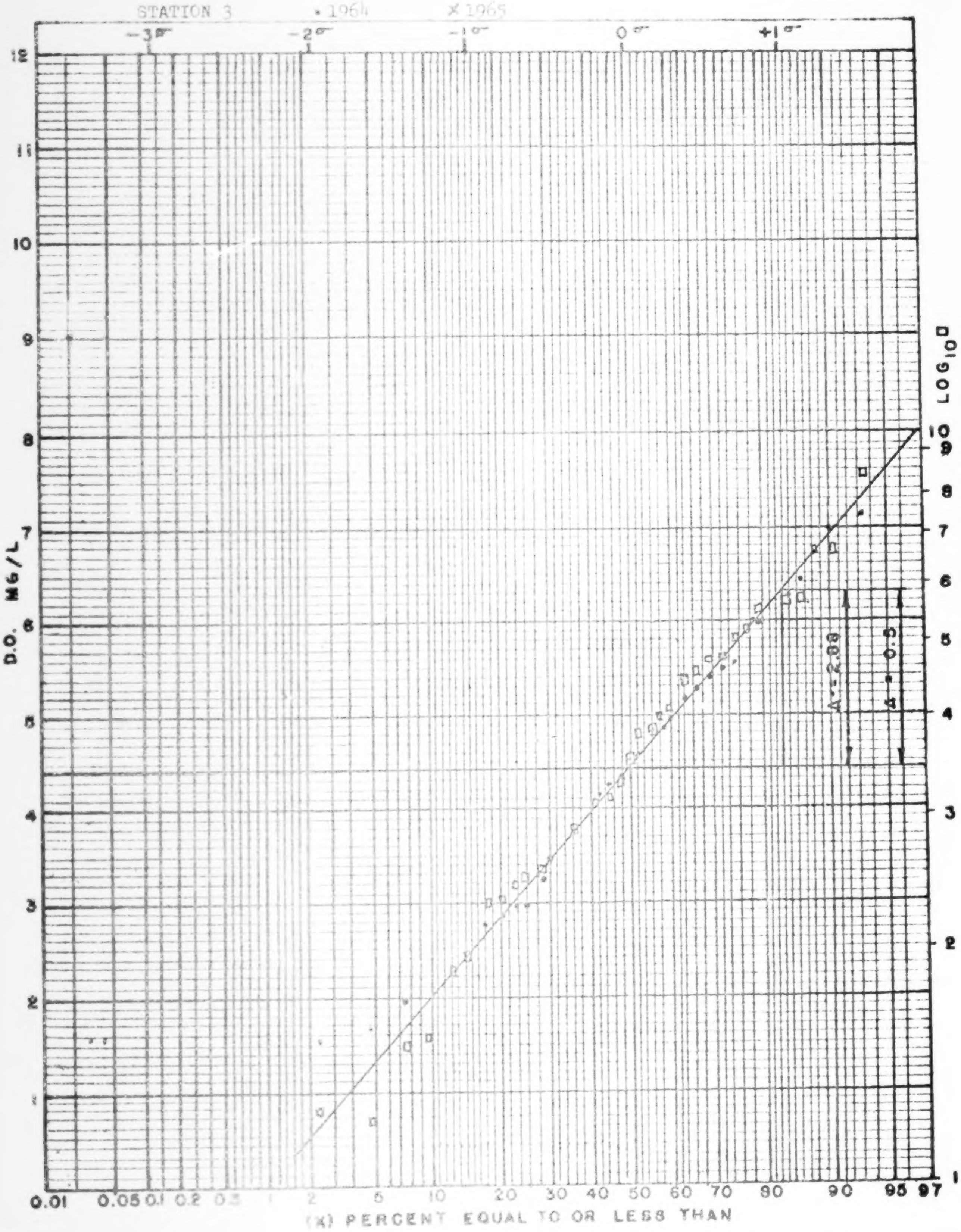


FIG. 3 Probability diagram of dissolved oxygen concentration at Station 3

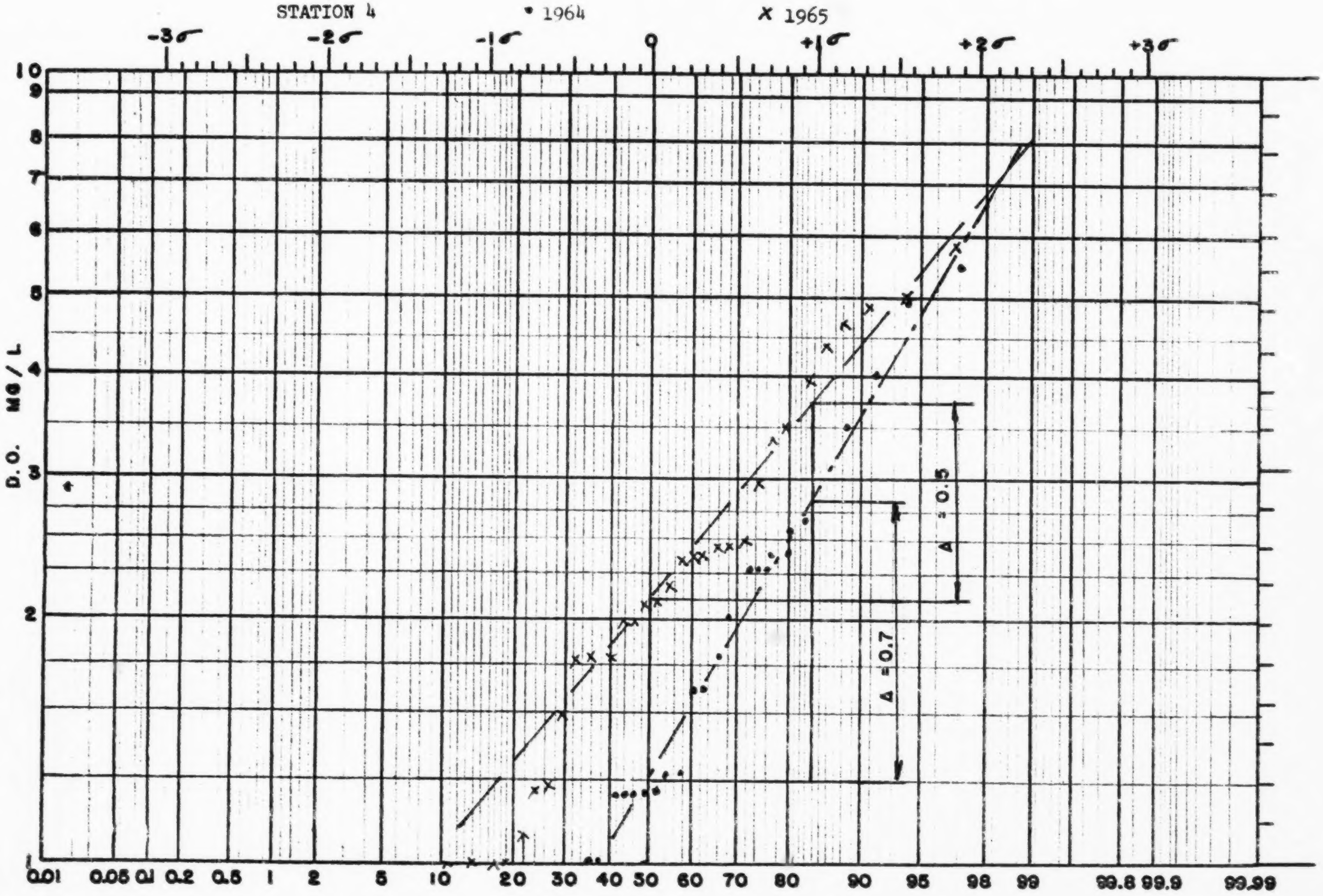


FIG. 4 Probability diagram of dissolved oxygen concentration at Station 4

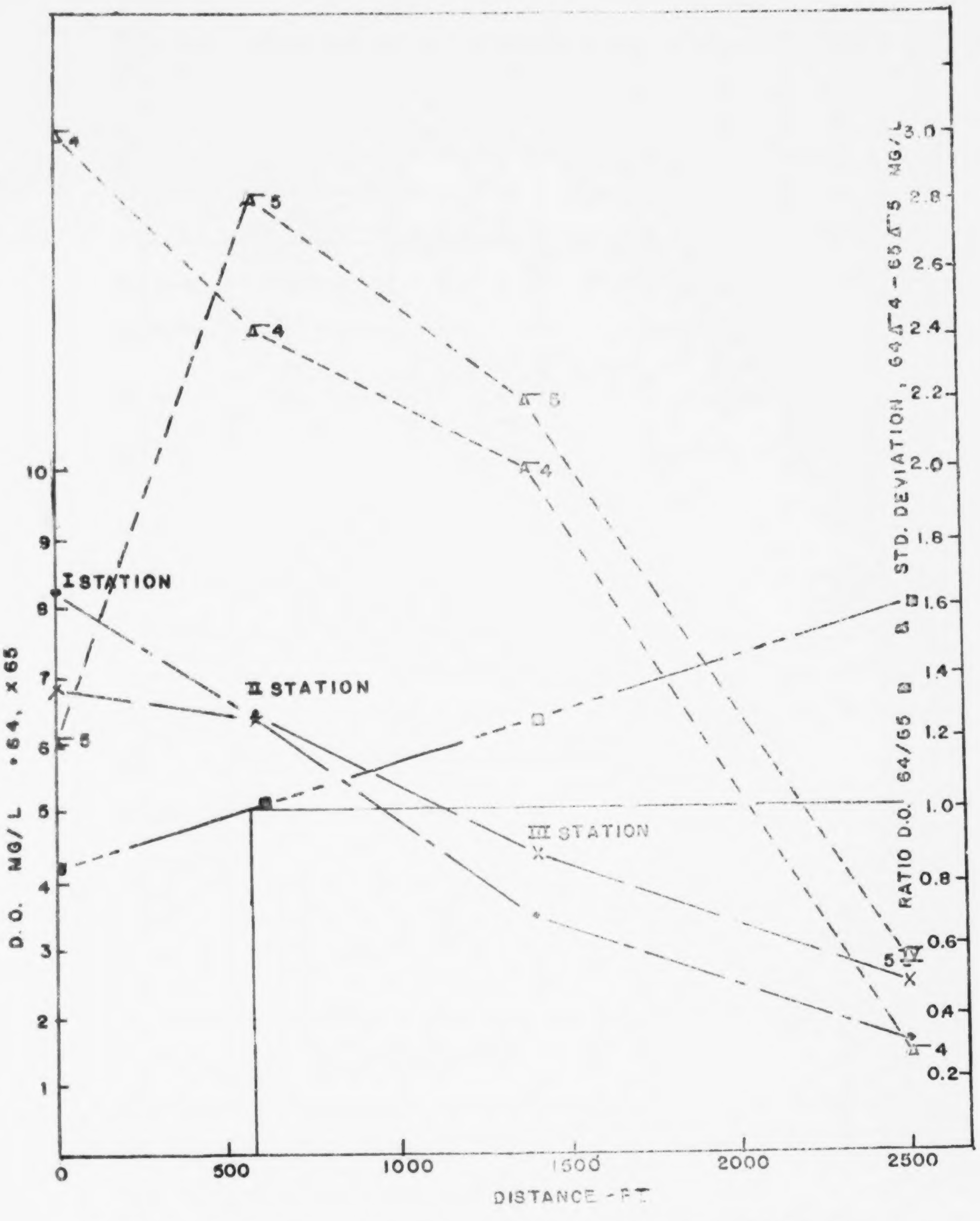


FIG. 5 Average dissolved oxygen concentration existing in basin area

TABLE XXIX

AVERAGE DISSOLVED OXYGEN (50%)

STATION	1964	1965	RATIO 64/65
1	6.8	8.2	0.83
2	6.4	6.2	1.03
3	4.3	3.4	1.26
4	2.4	1.5	1.60

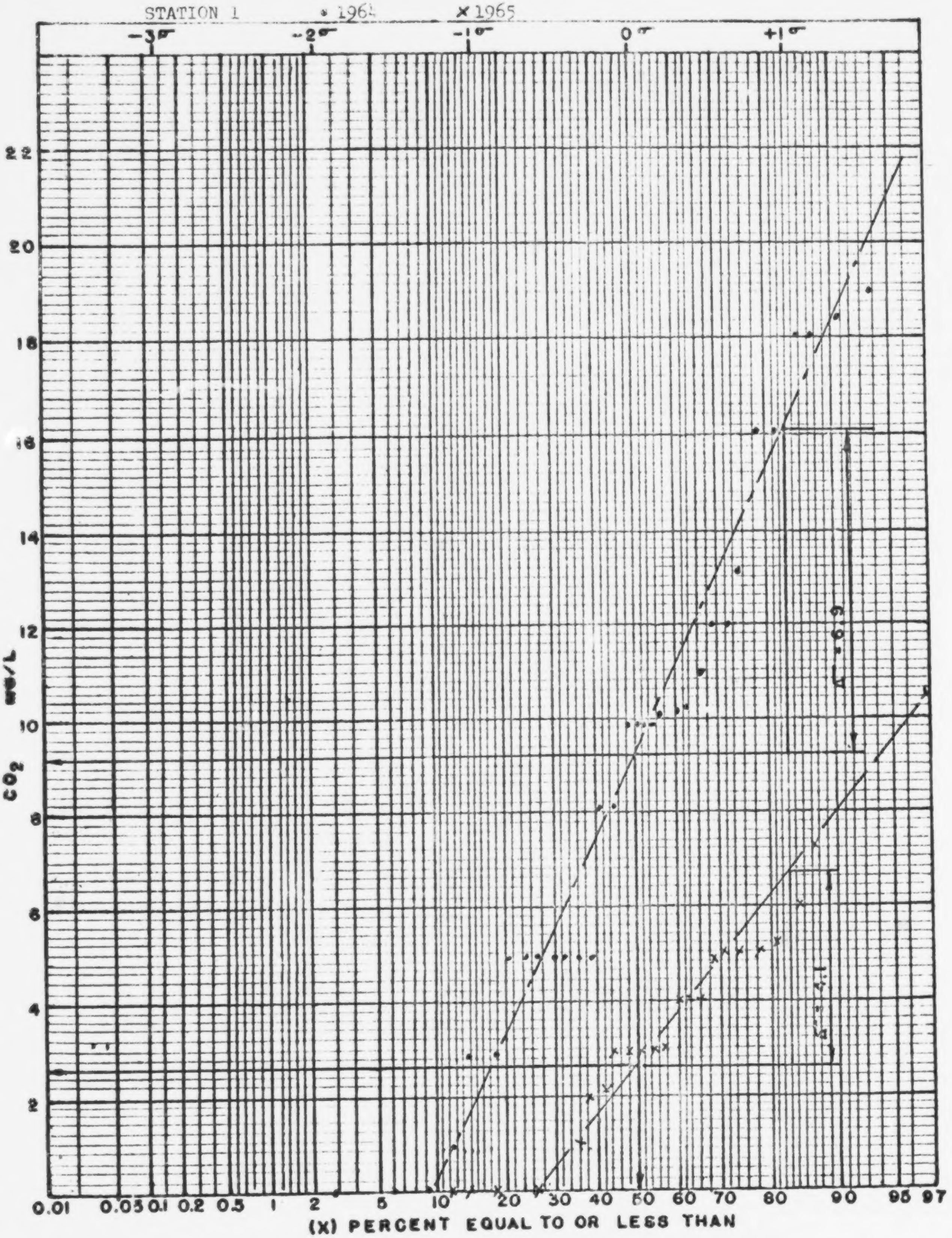


FIG. 6 Probability diagram of carbon dioxide concentration at Station 1

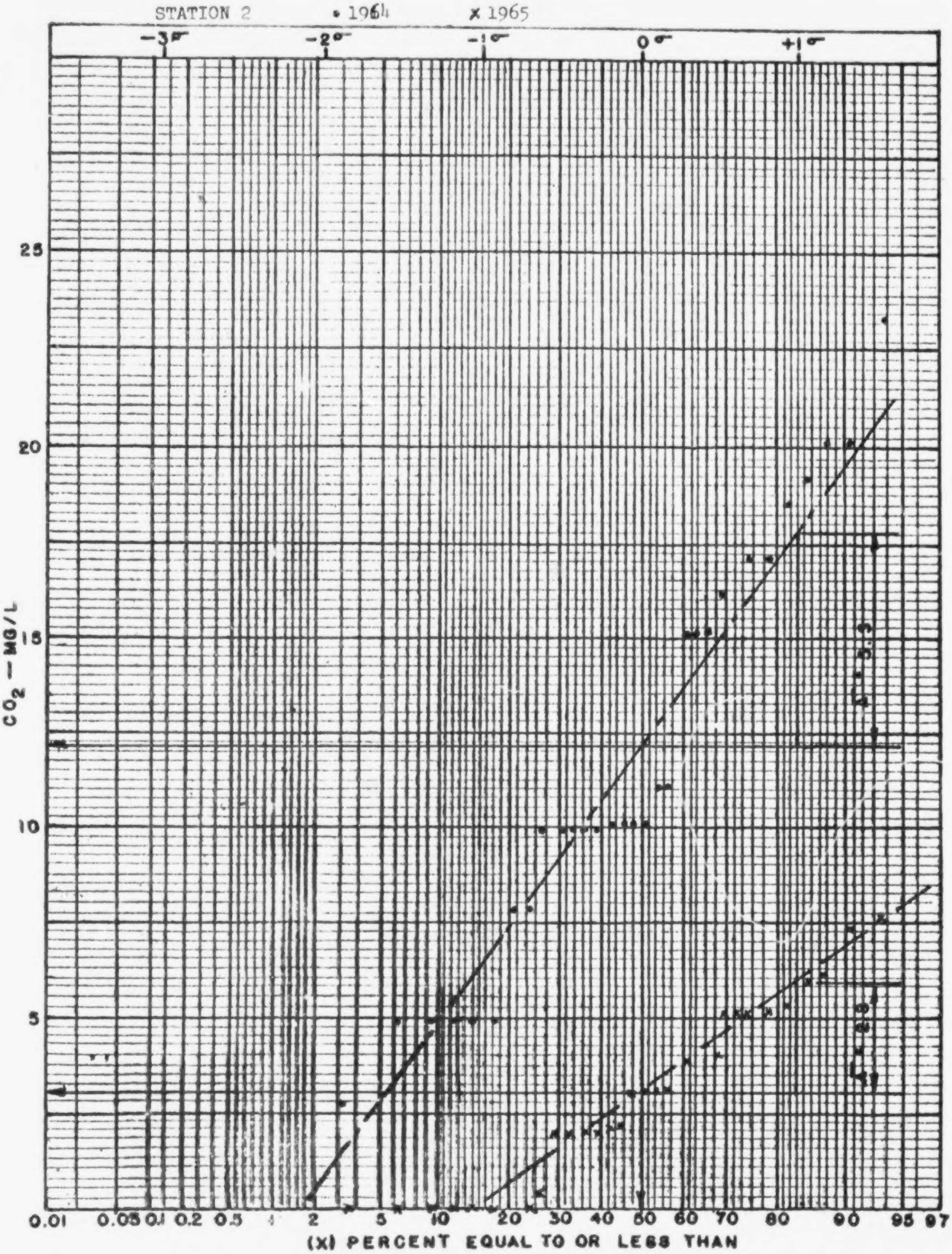


FIG. 7 Probability diagram of carbon dioxide concentration at Station 2

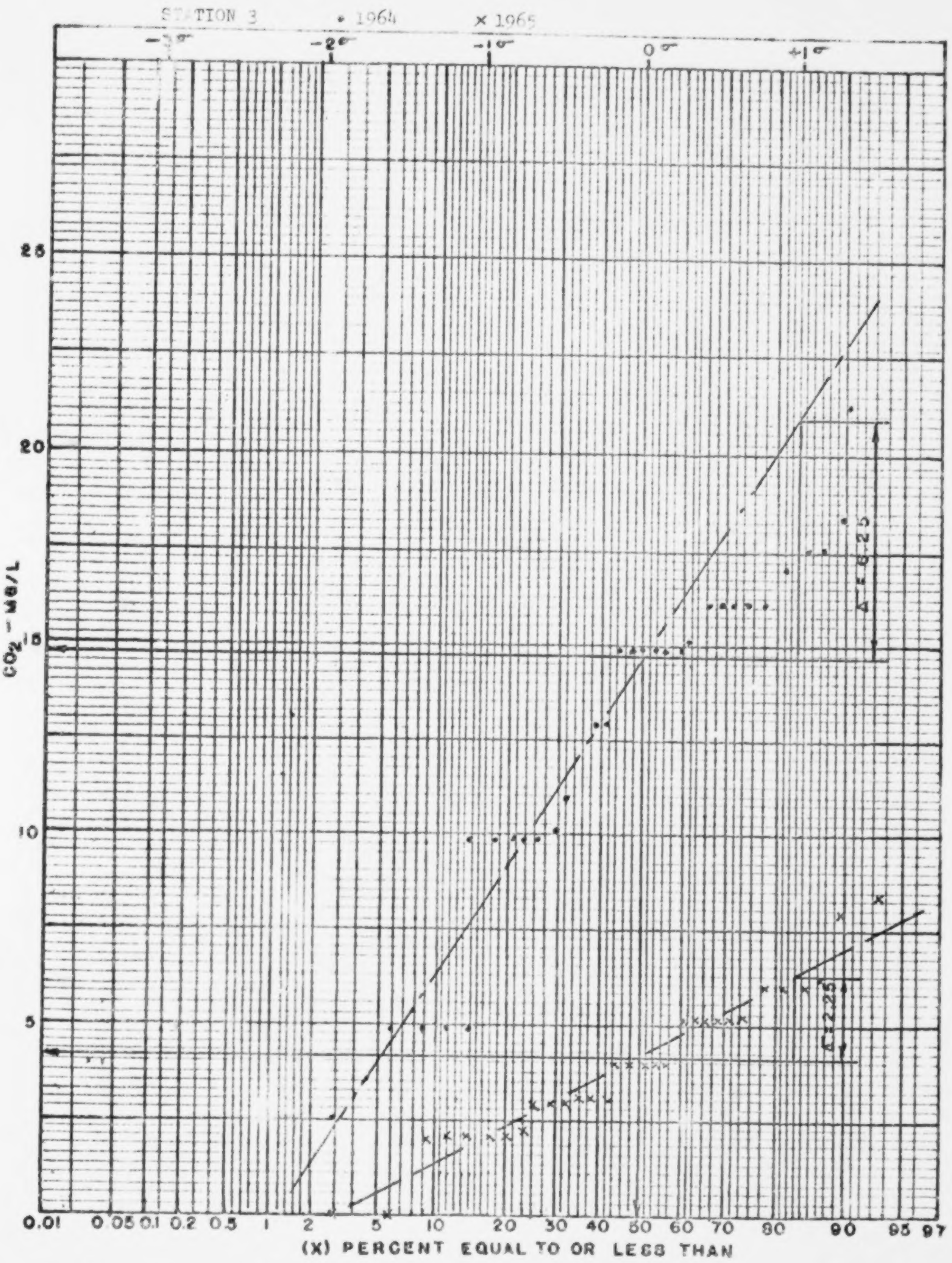


FIG. 8 Probability diagram of carbon dioxide concentration at Station 3

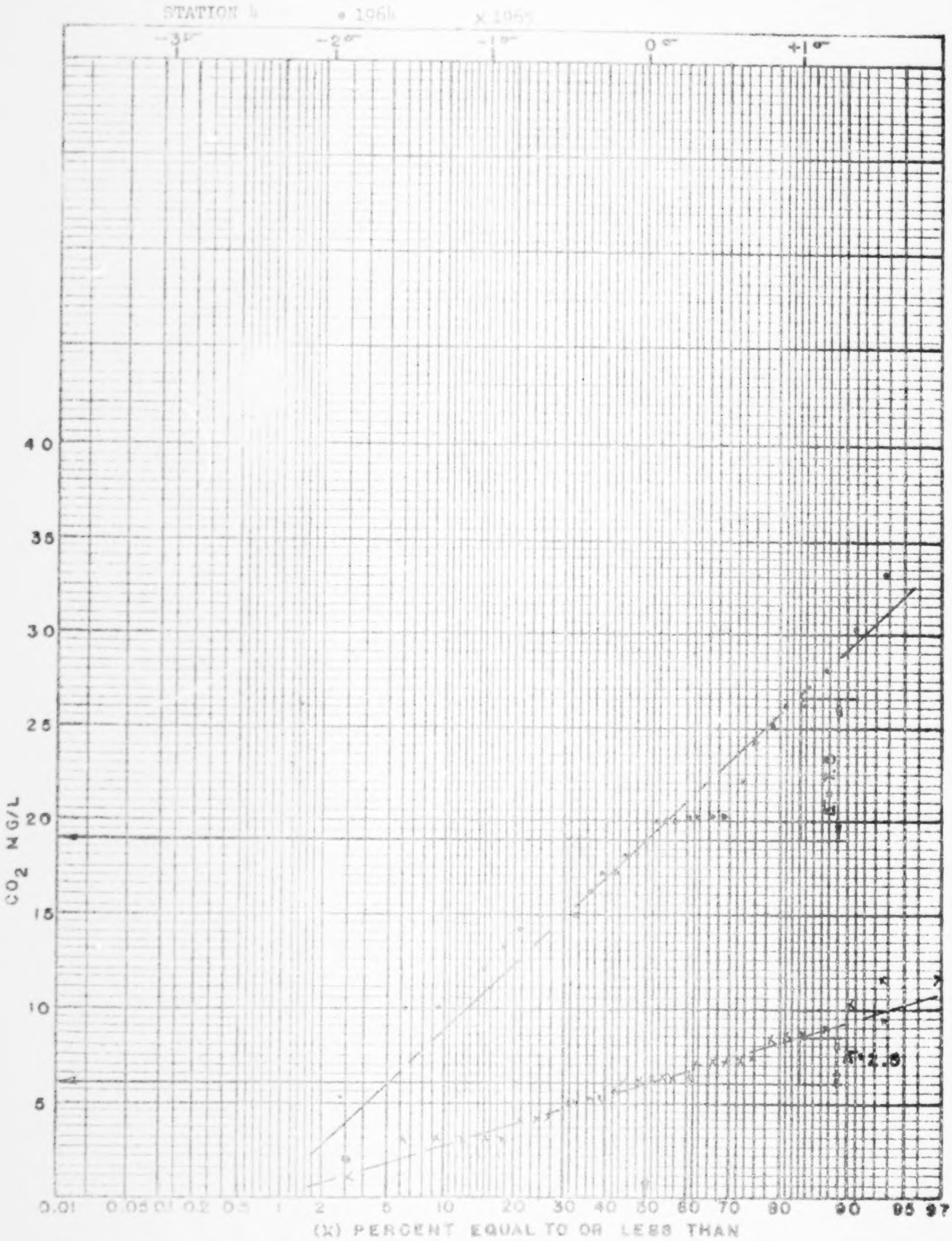


FIG. 9 Probability diagram of carbon dioxide concentration at Station 4

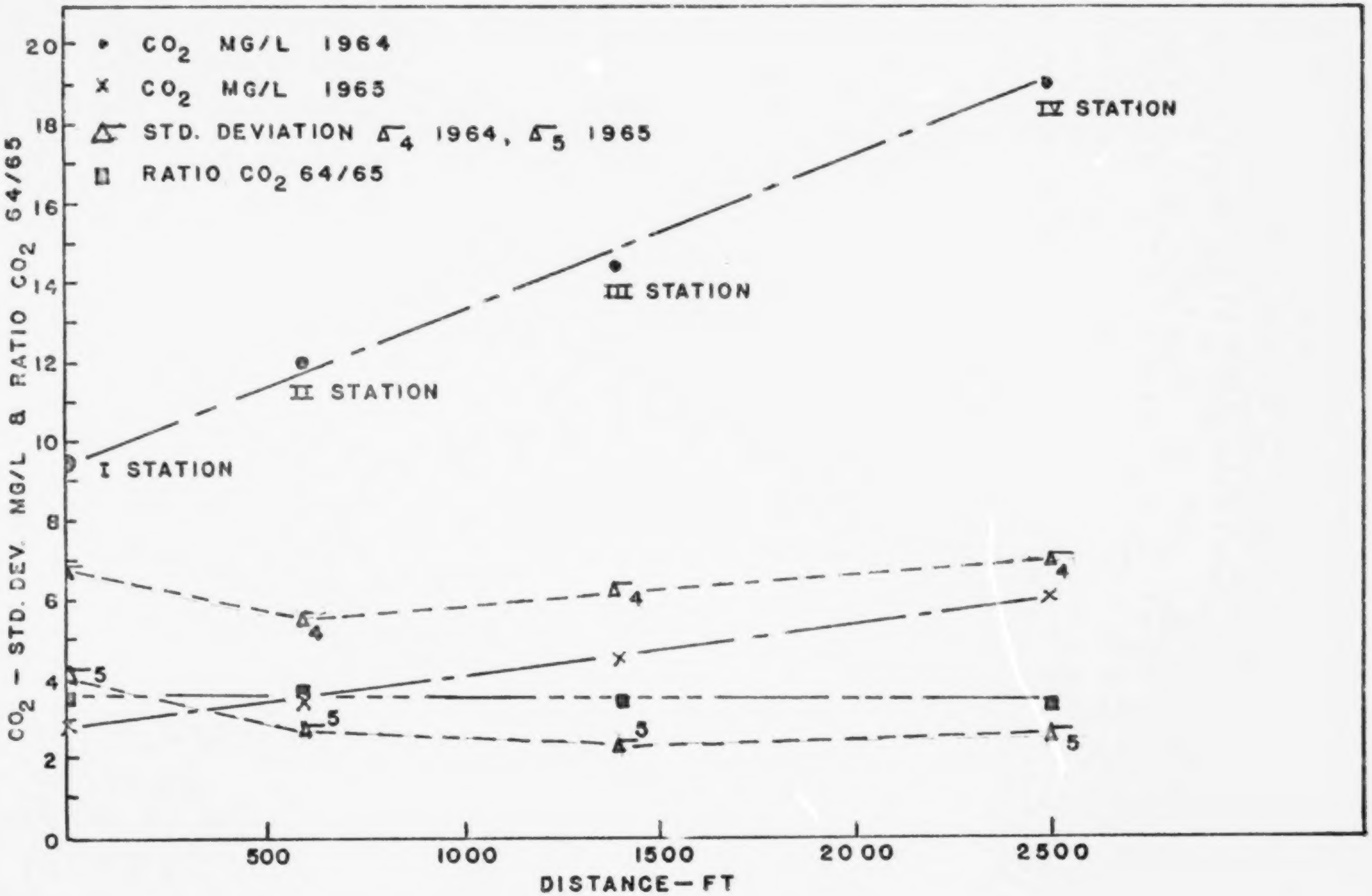


FIG. 10 Average carbon dioxide concentrations existing in basin area

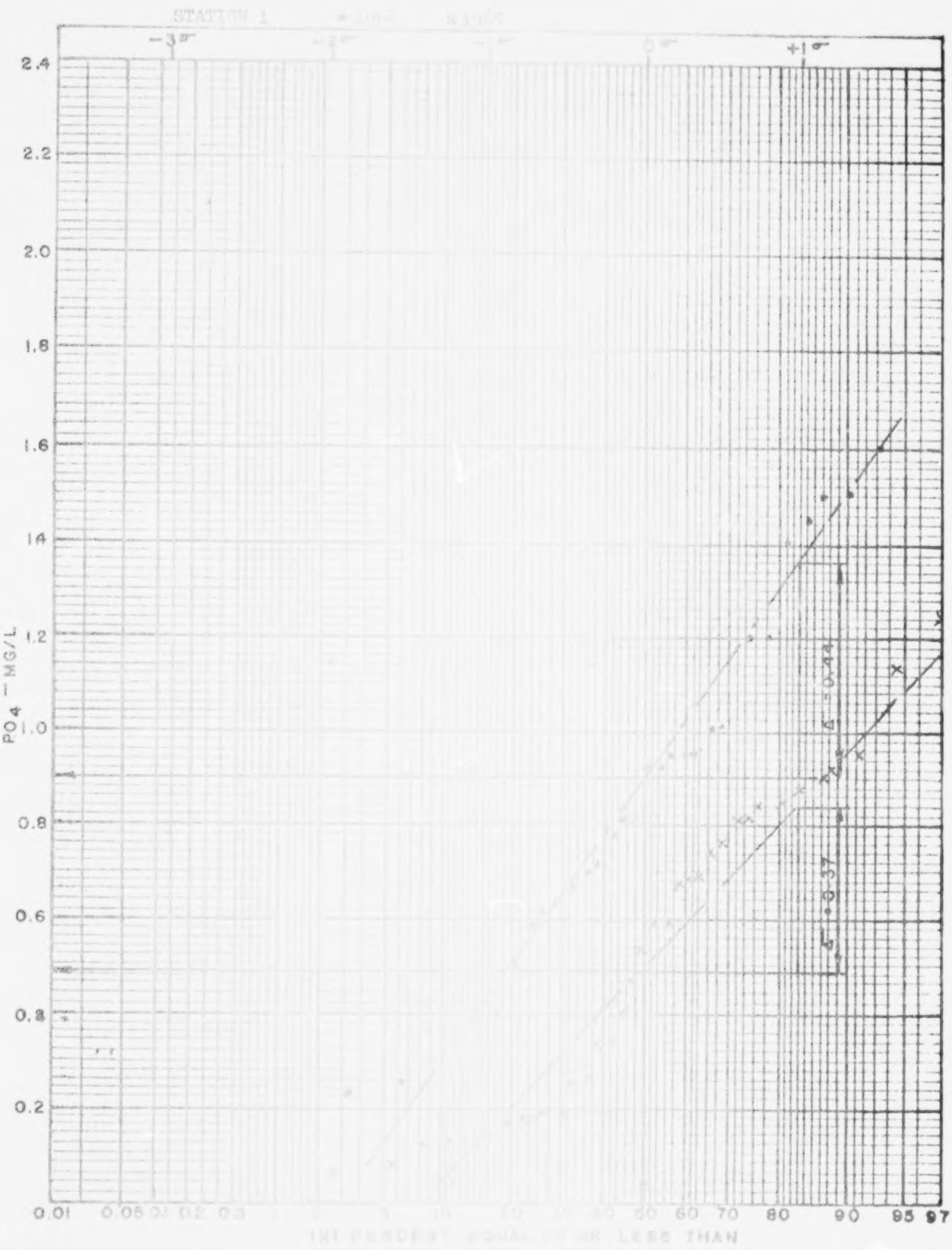


FIG. 11 Probability diagram of phosphate concentrations at Station 1

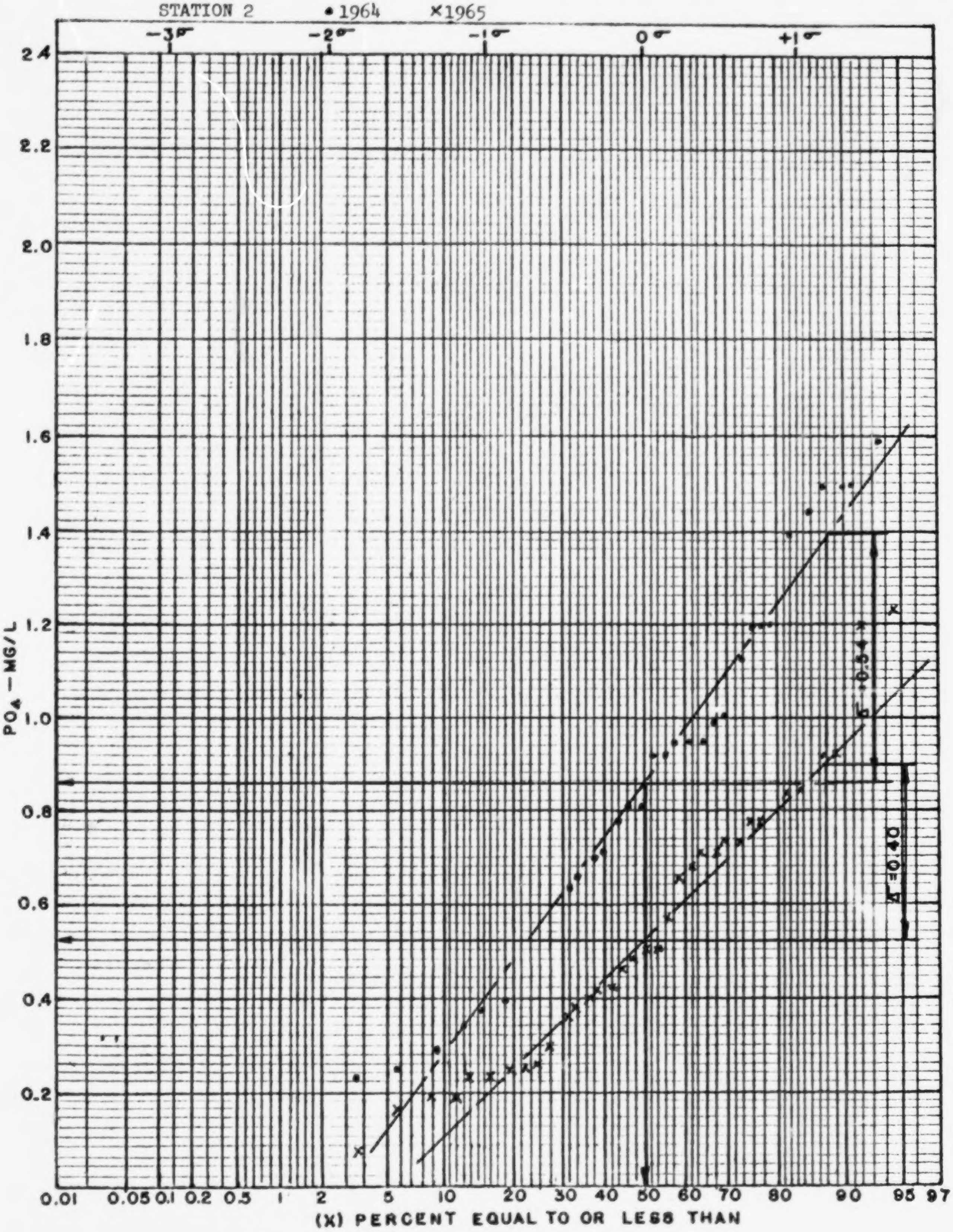


FIG. 12 Probability diagram of phosphate concentration at Station 2

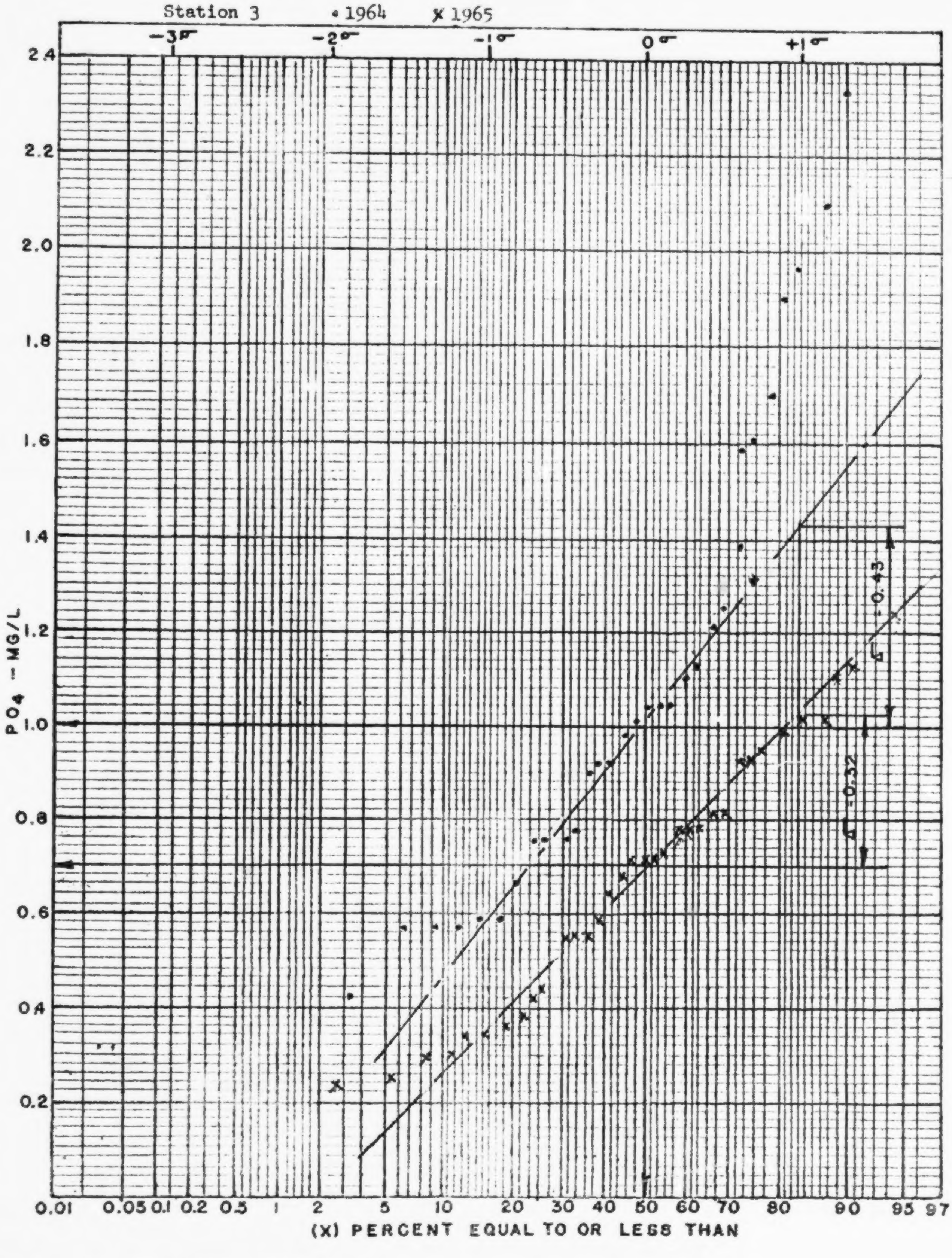


FIG. 13 Probability diagram of phosphate concentration at Station 3

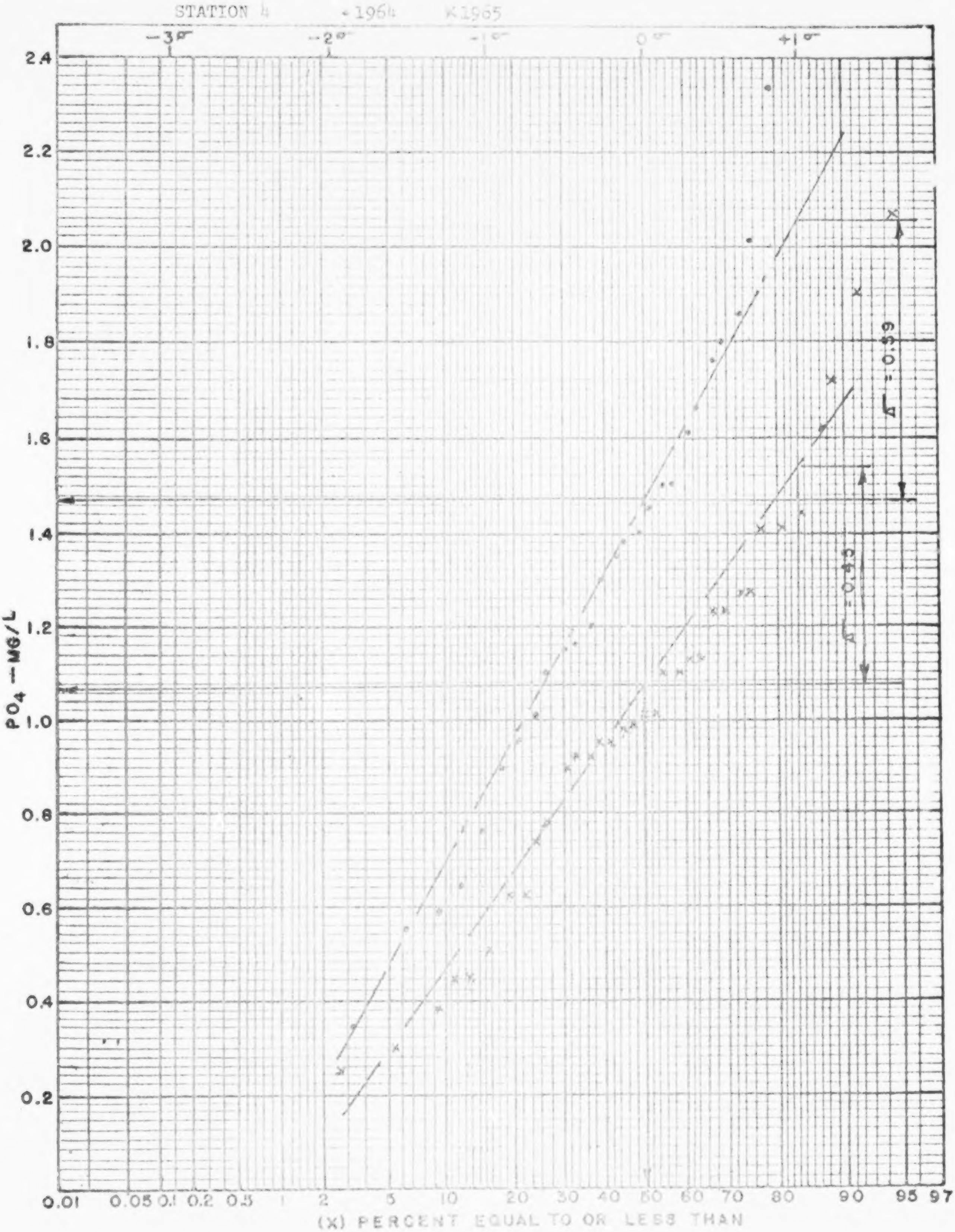


FIG. 14 Probability diagram of phosphate concentration at Station 4

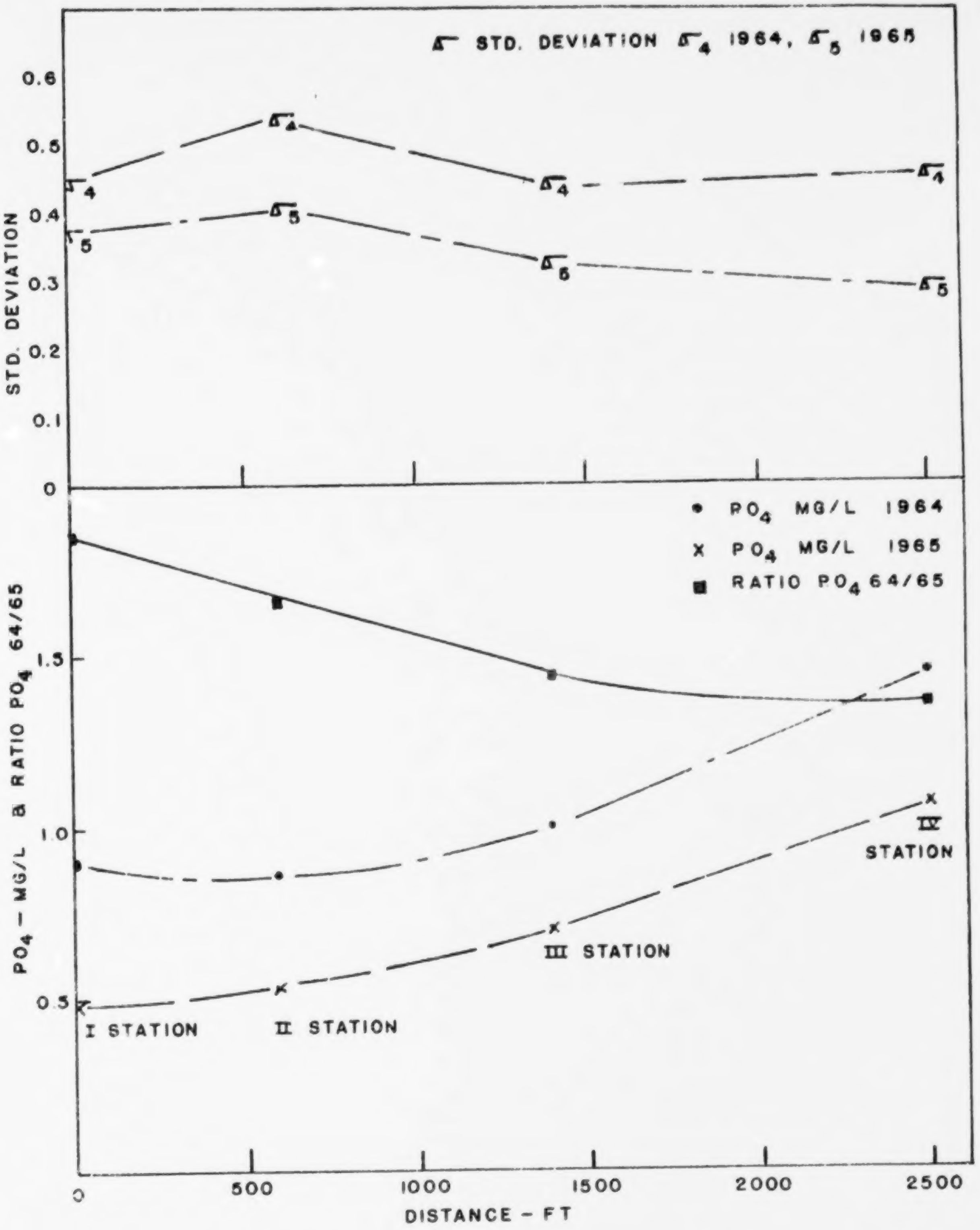


Fig. 15 Average phosphate concentration in basin area

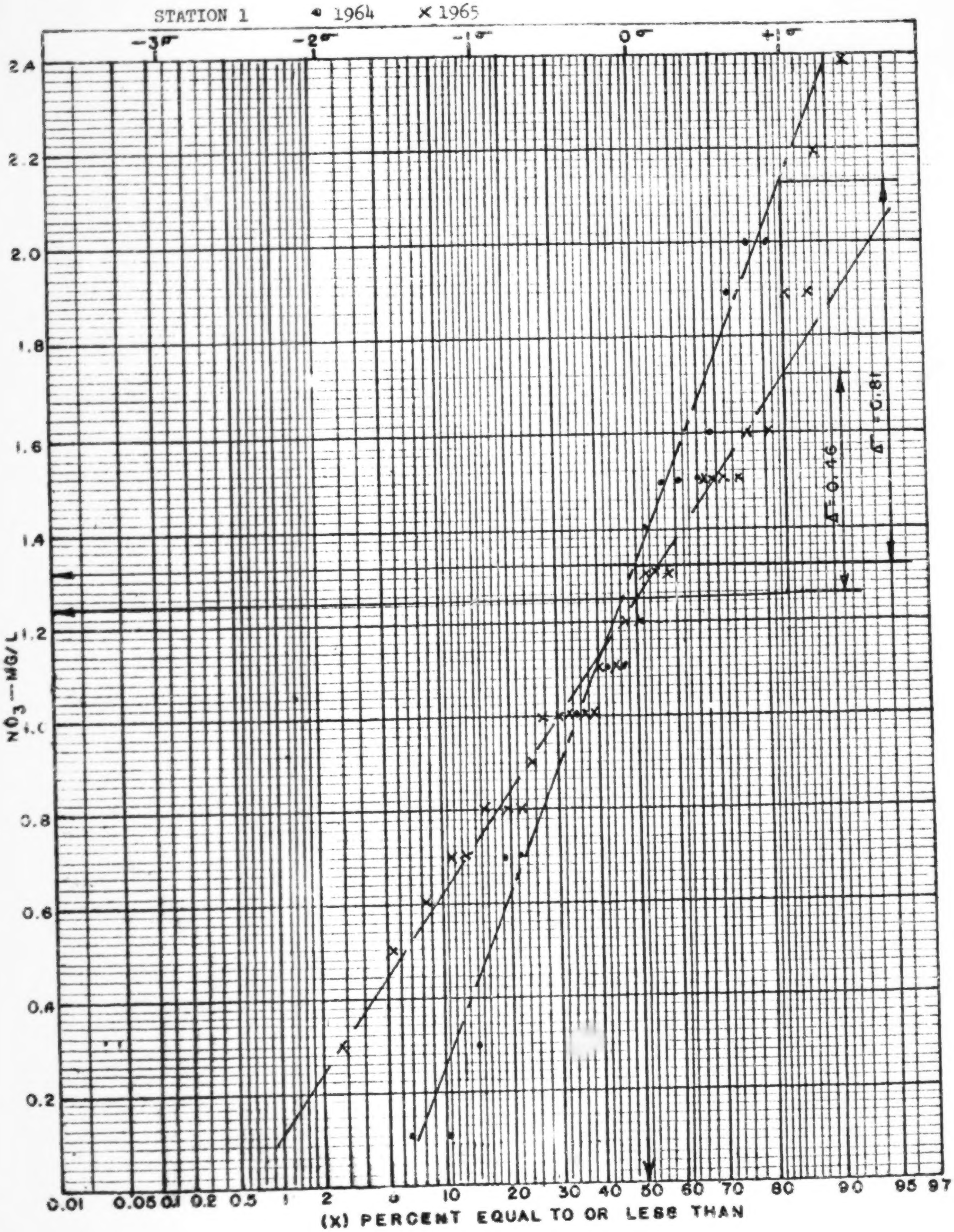


FIG. 16 Probability diagram of nitrate level at Station 1

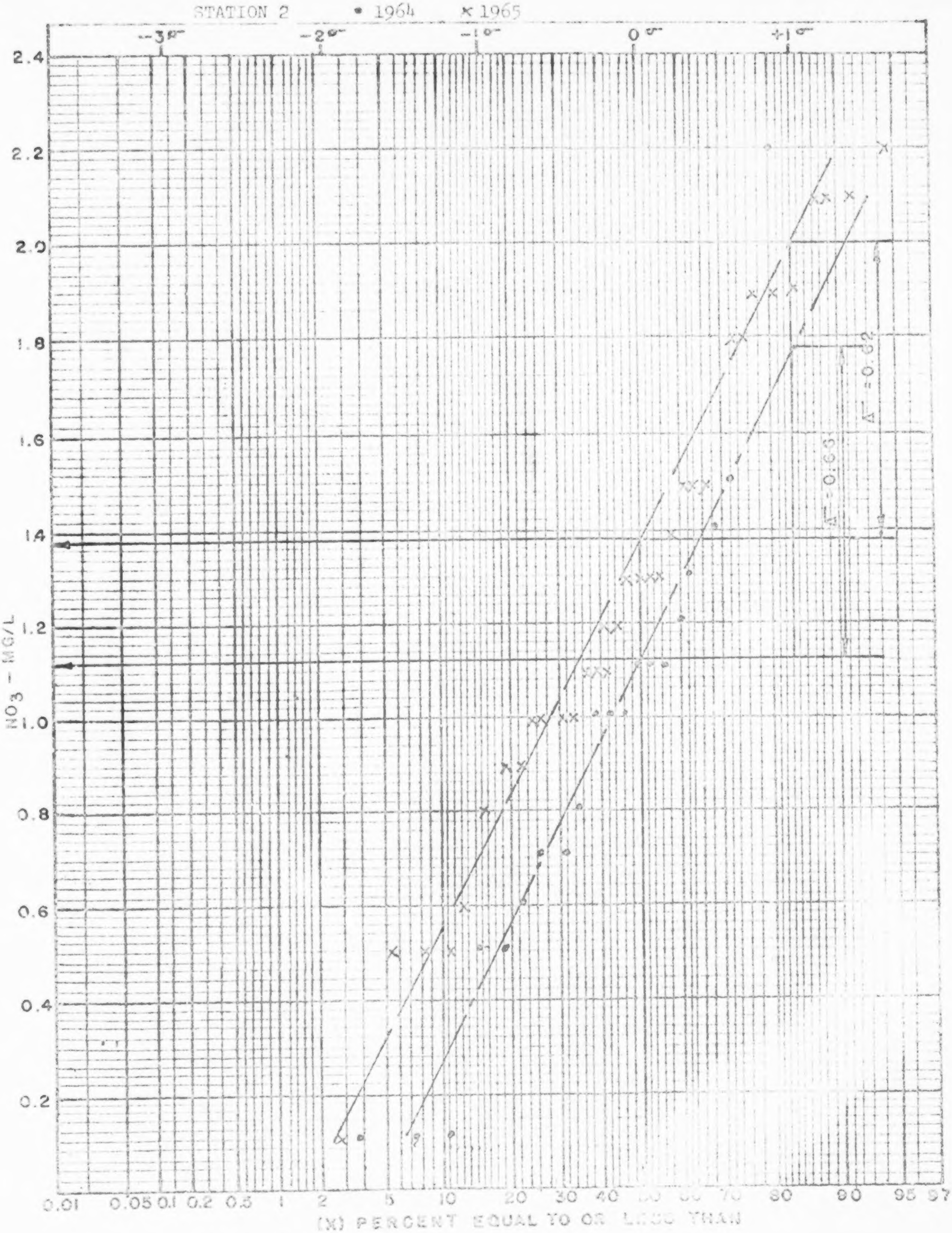


FIG. 17 Probability diagram of nitrate level at Station 2

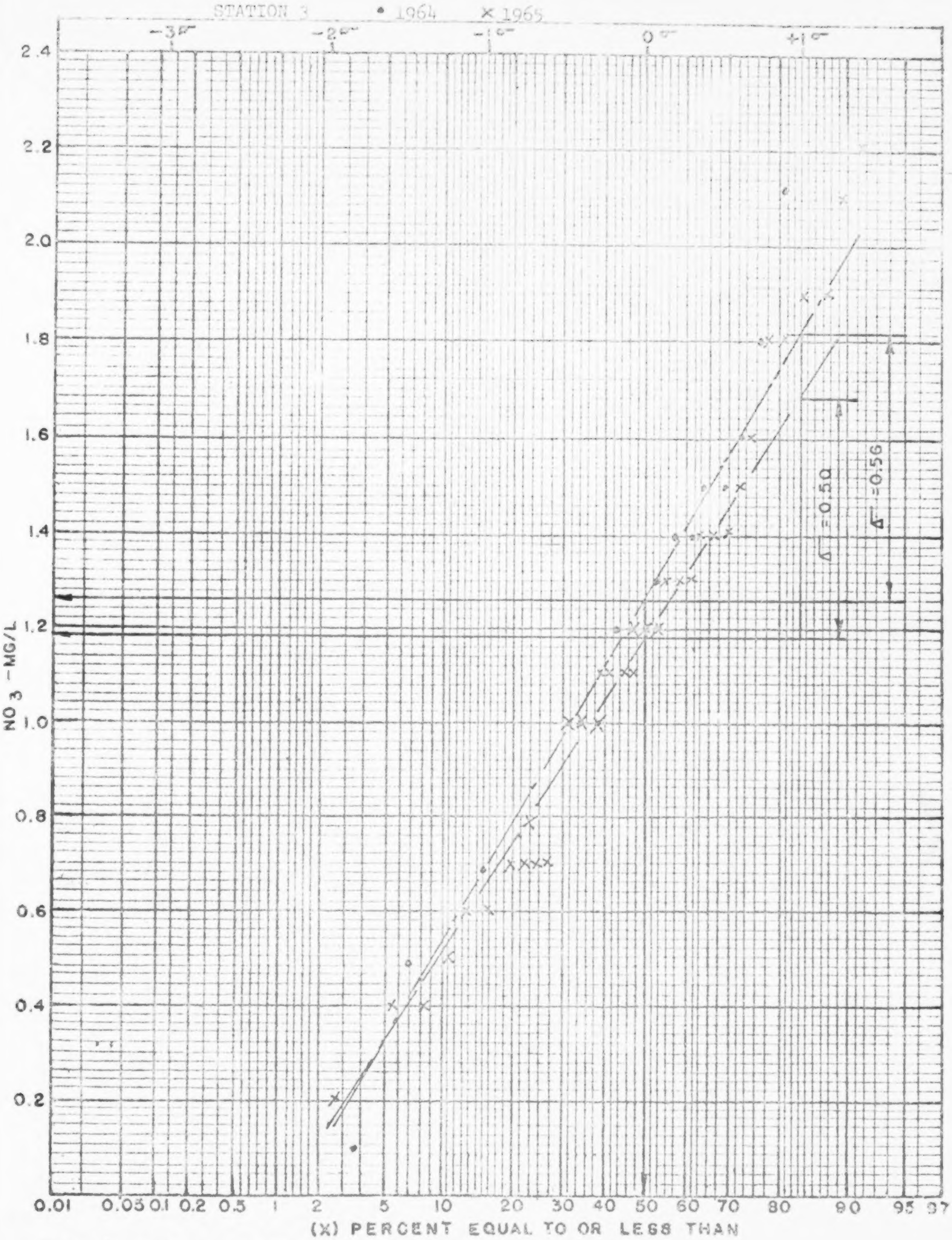


FIG. 18 Probability diagram of nitrate level at Station 3

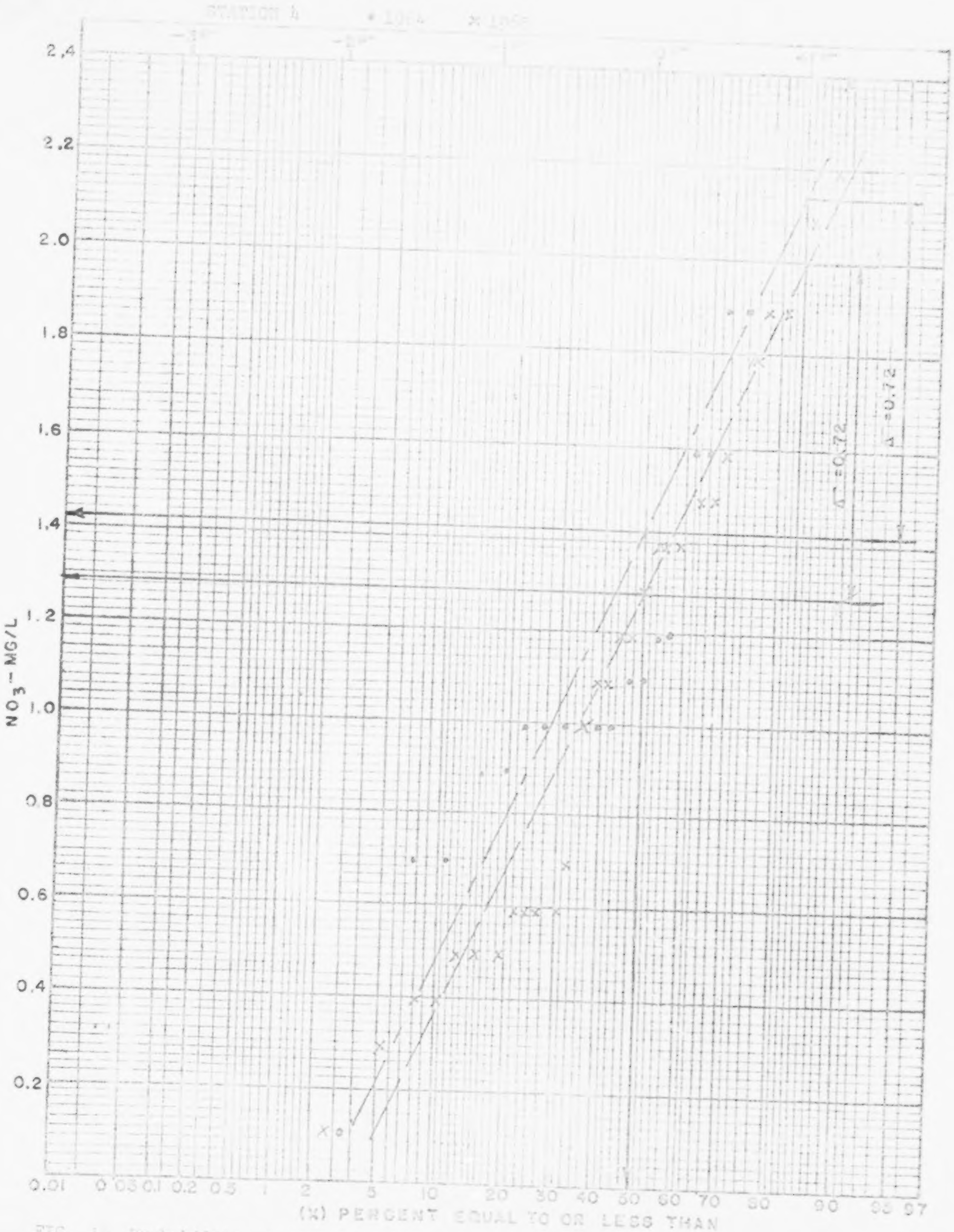


FIG. 15 Probability diagram of nitrate level at Station 4

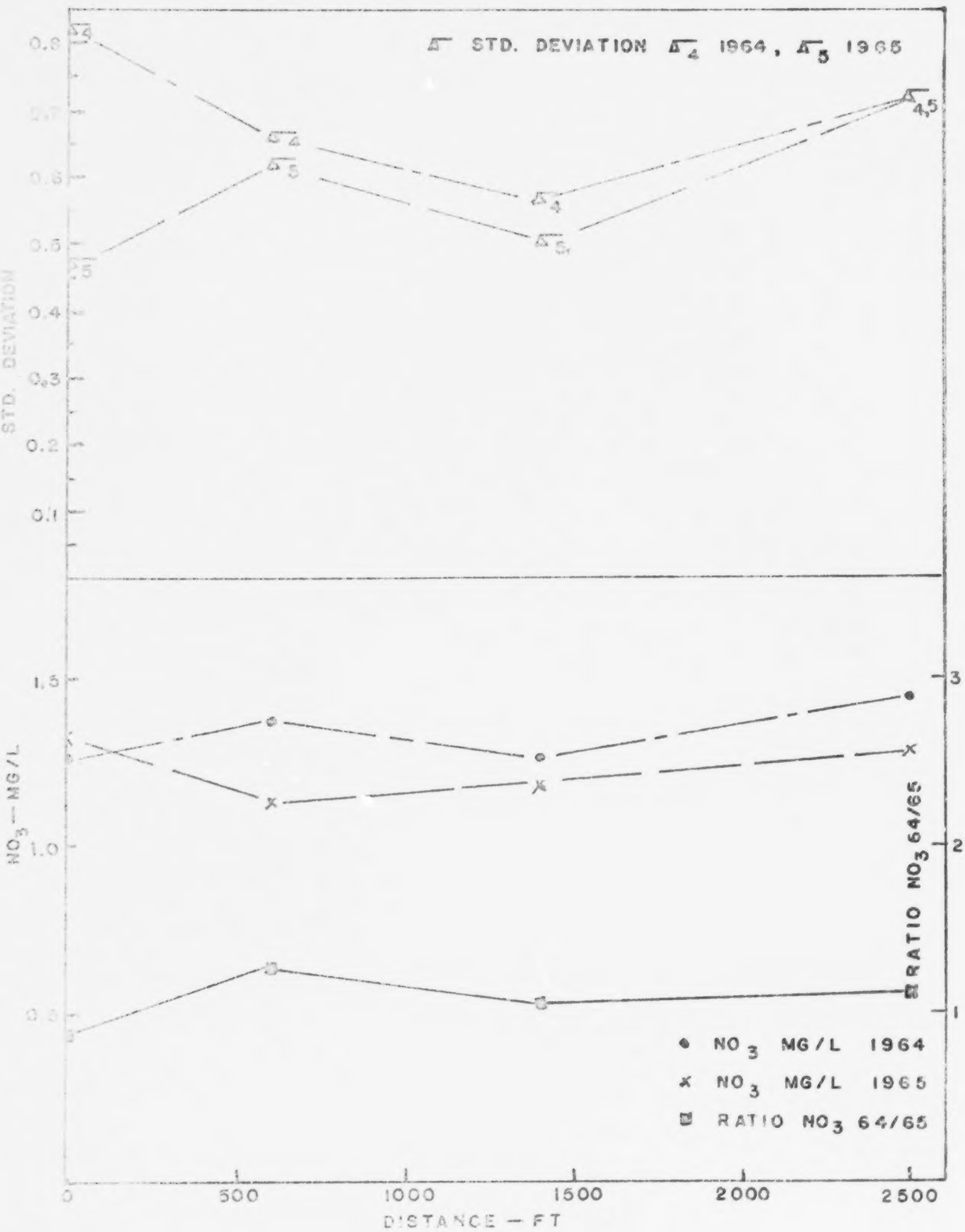


FIG. 20 Average nitrate levels existing in basin area

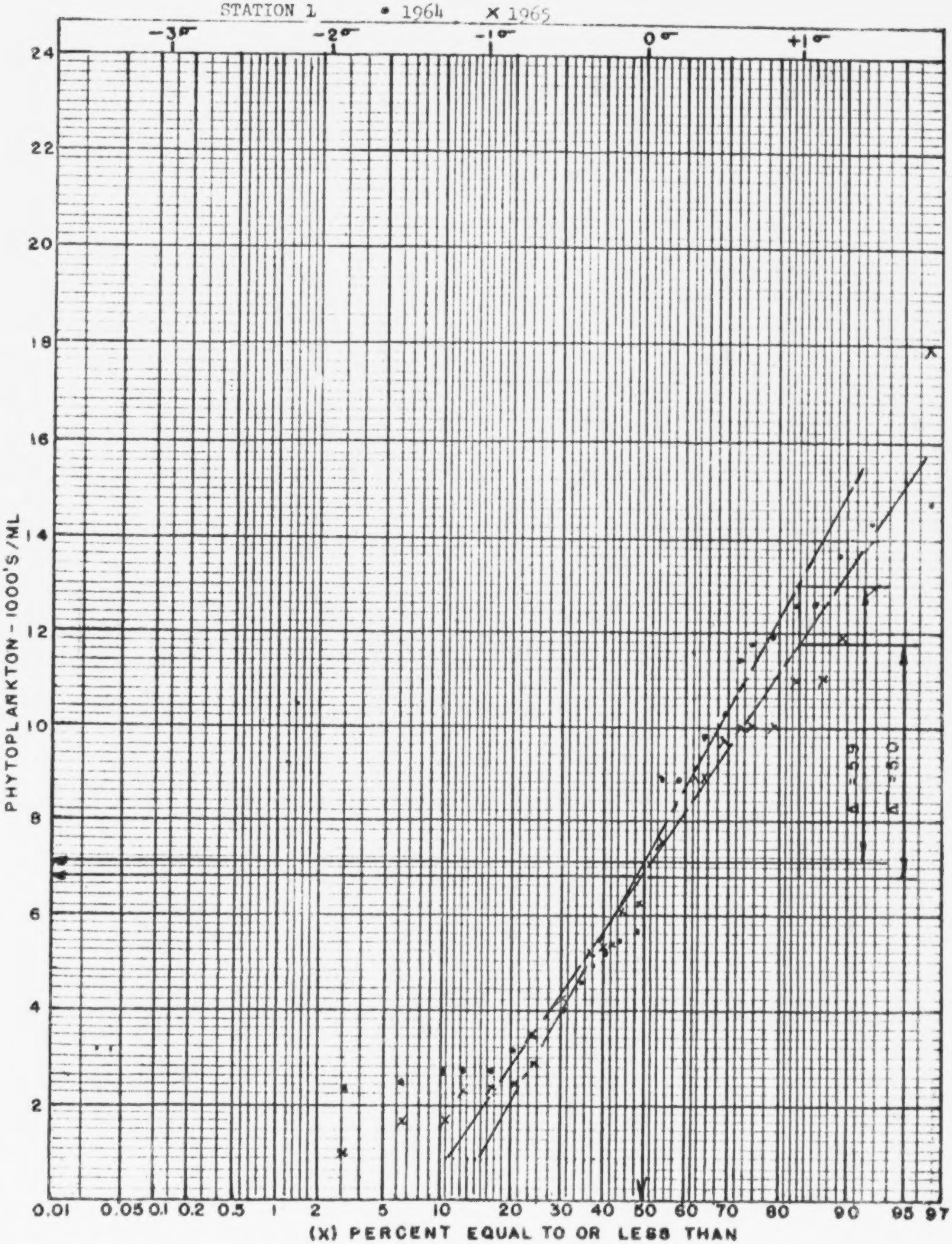


FIG. 21 Probability diagram of numbers of phytoplankton at Station 1

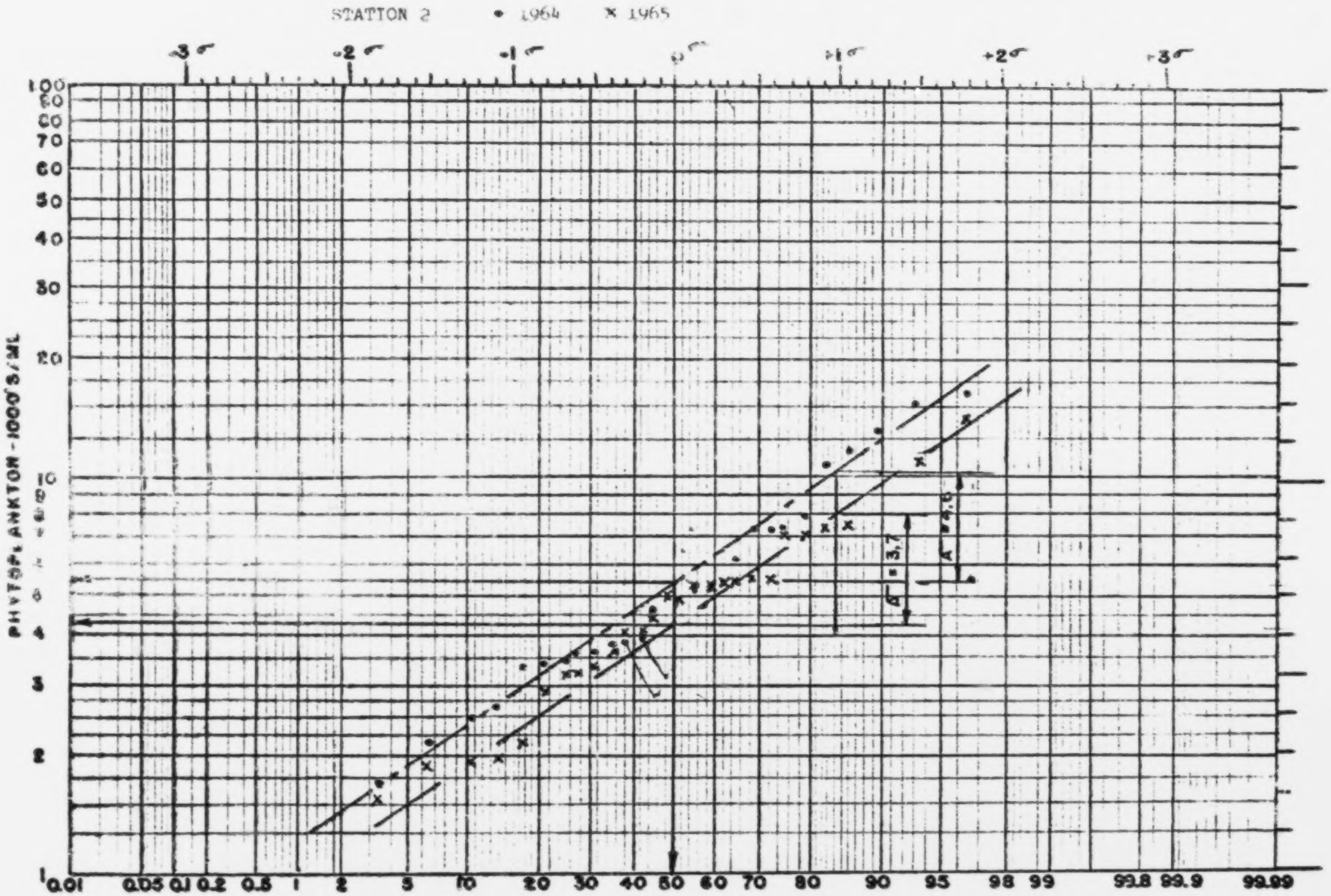


FIG. 22 Probability diagram of numbers of phytoplankton at Station 2

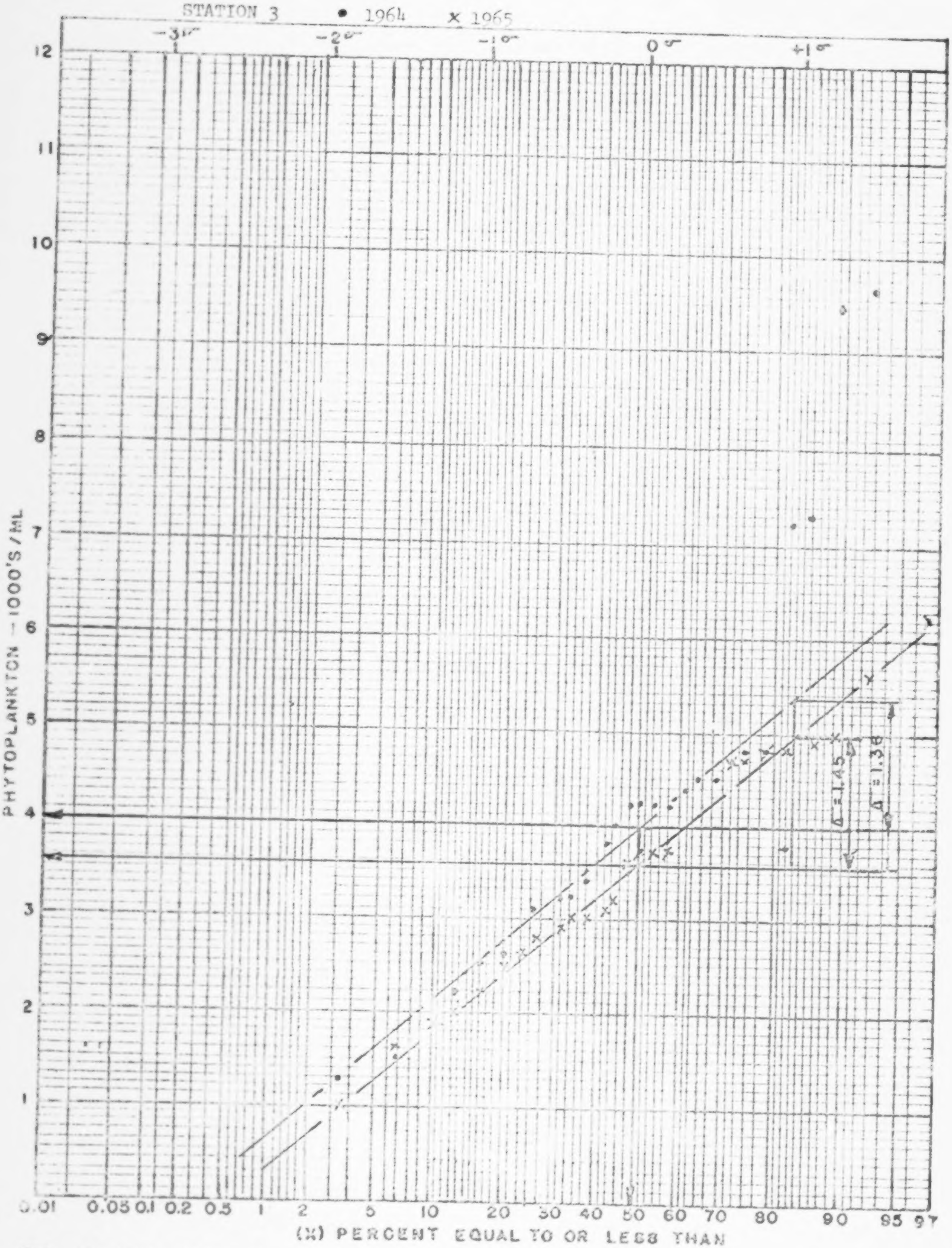


FIG. 23 Probability diagram of numbers of phytoplankton at Station 3

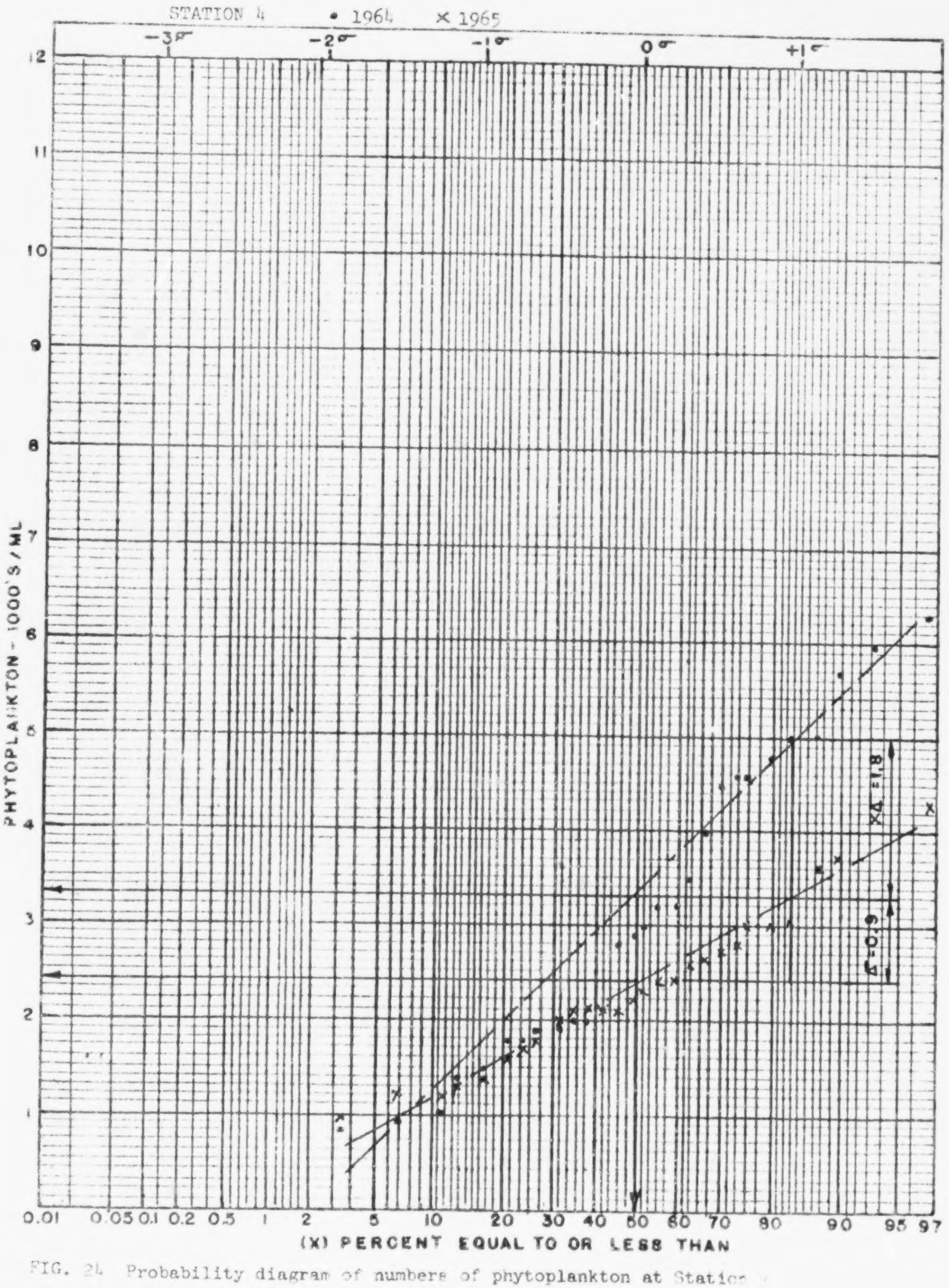


FIG. 24 Probability diagram of numbers of phytoplankton at Station 4

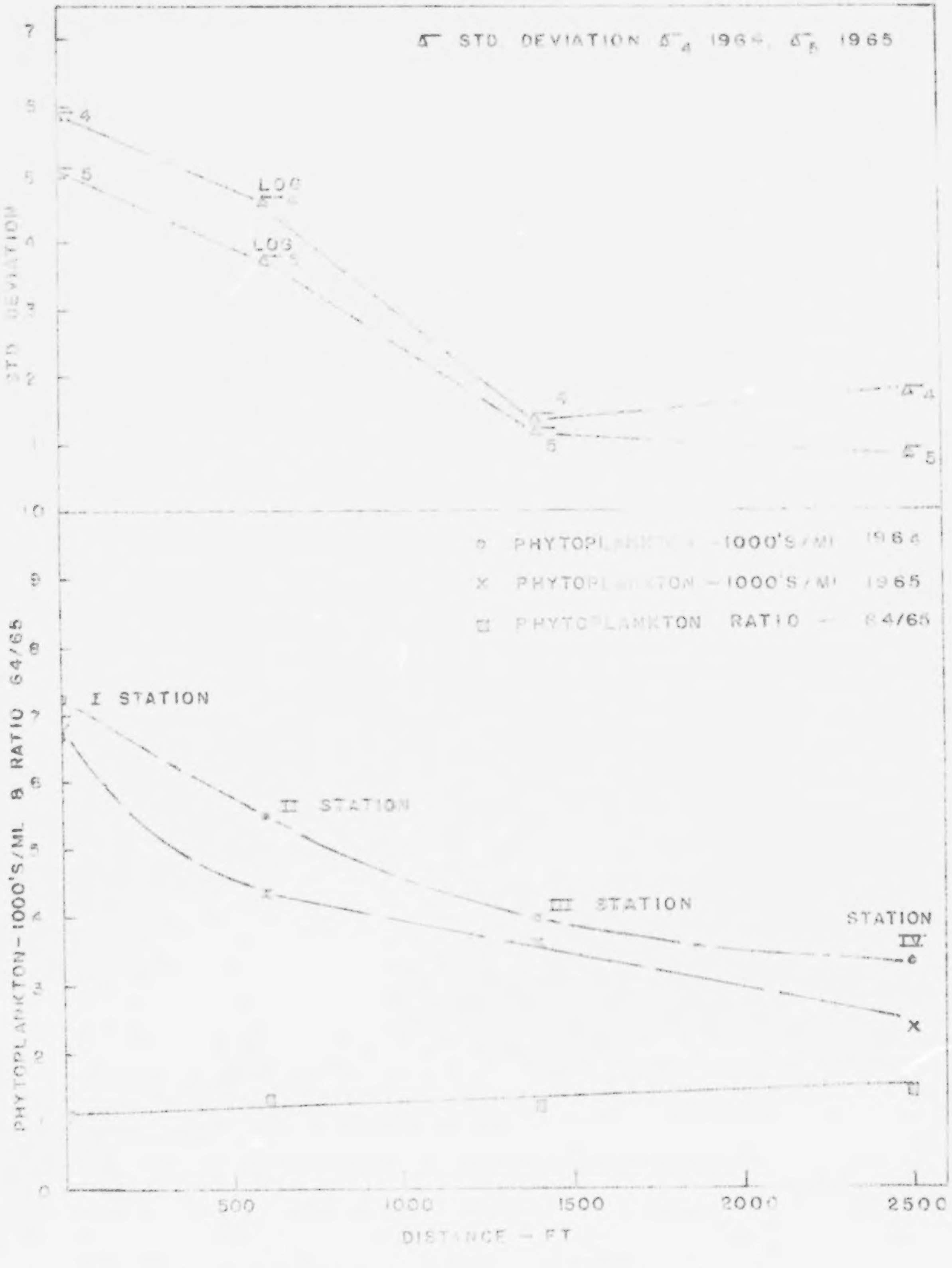


FIG. 25 Average number of phytoplankton in basin area.

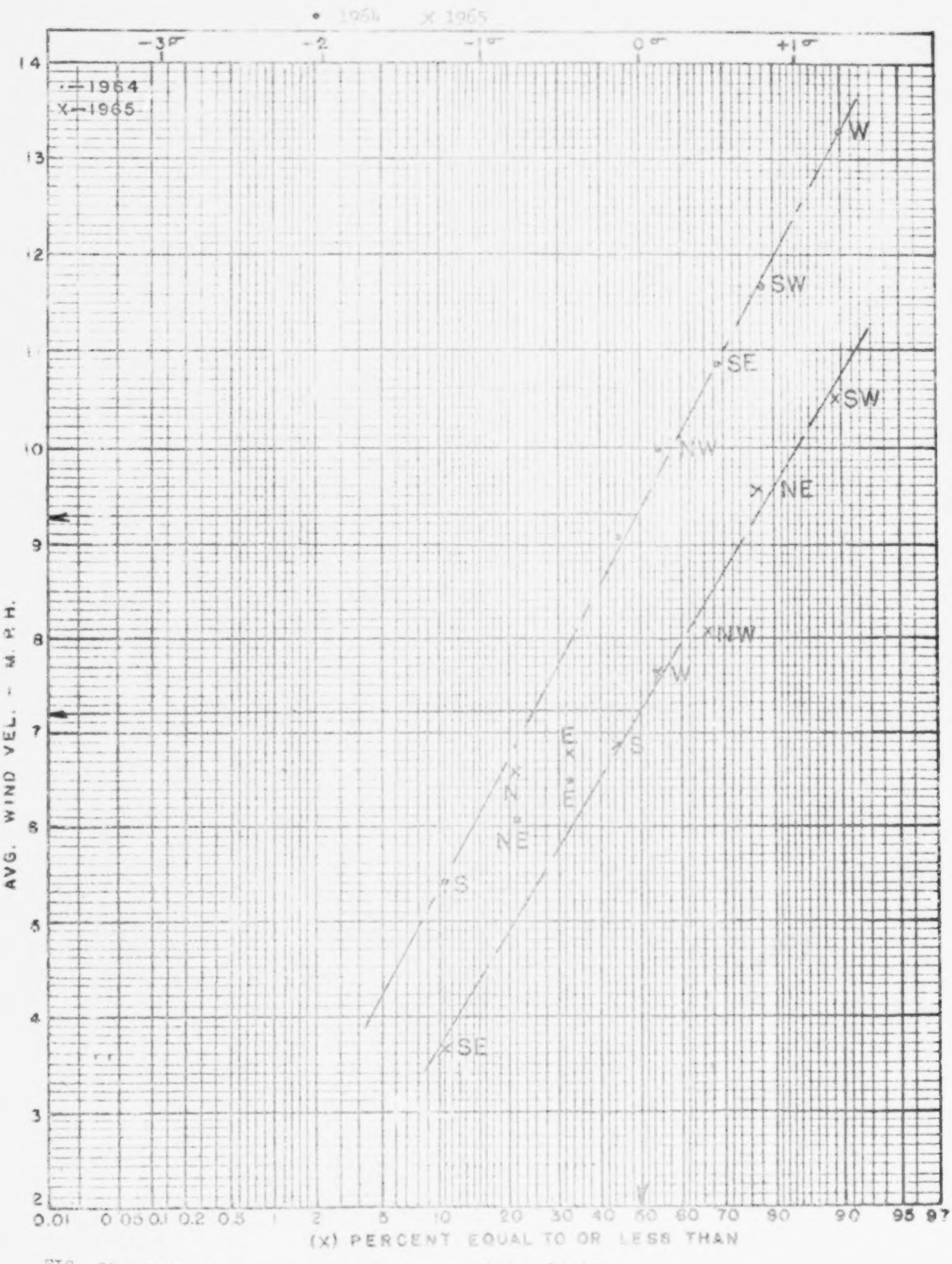


FIG. 26 Probability diagram of average wind velocity

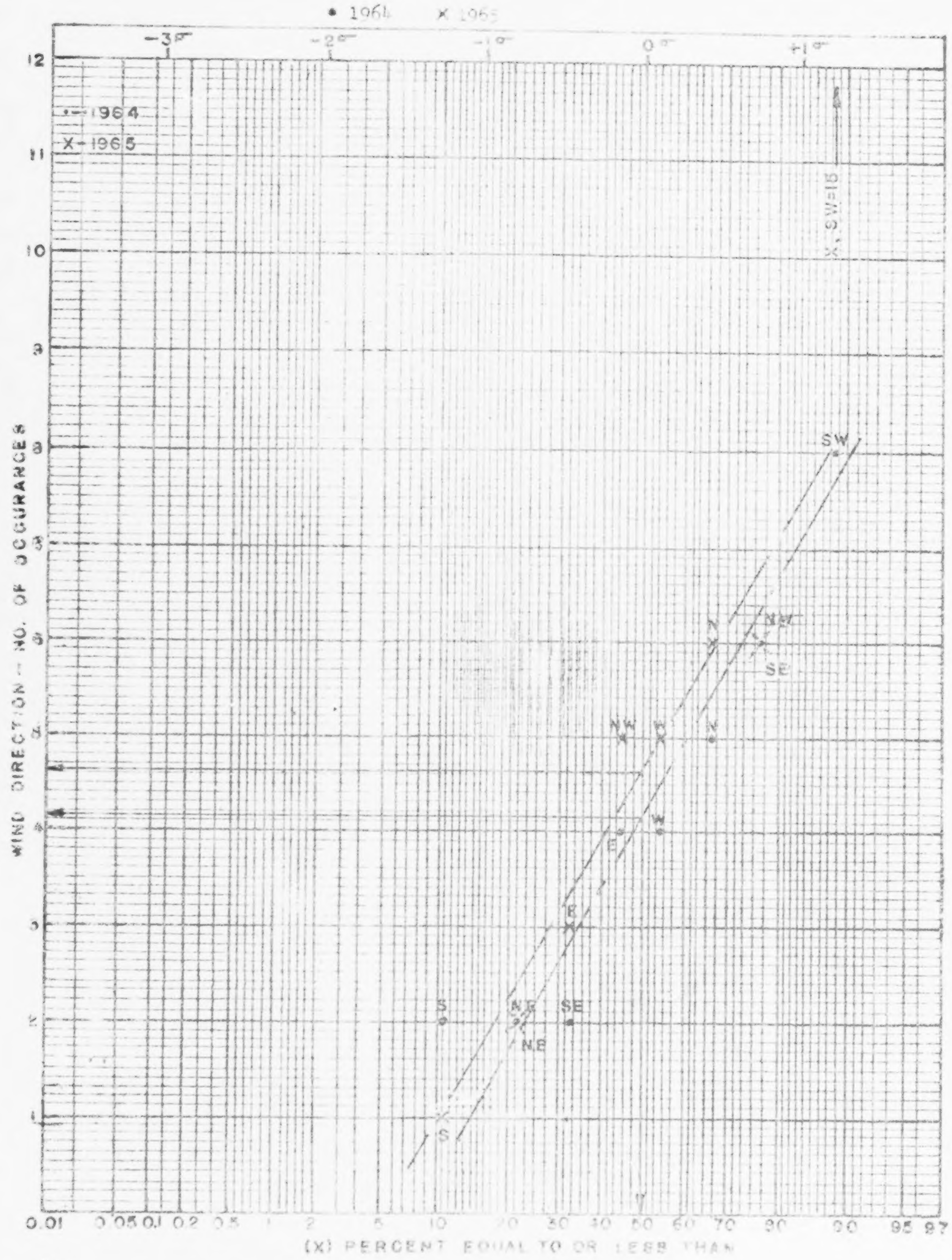


FIG. 37 Probability diagram of wind direction

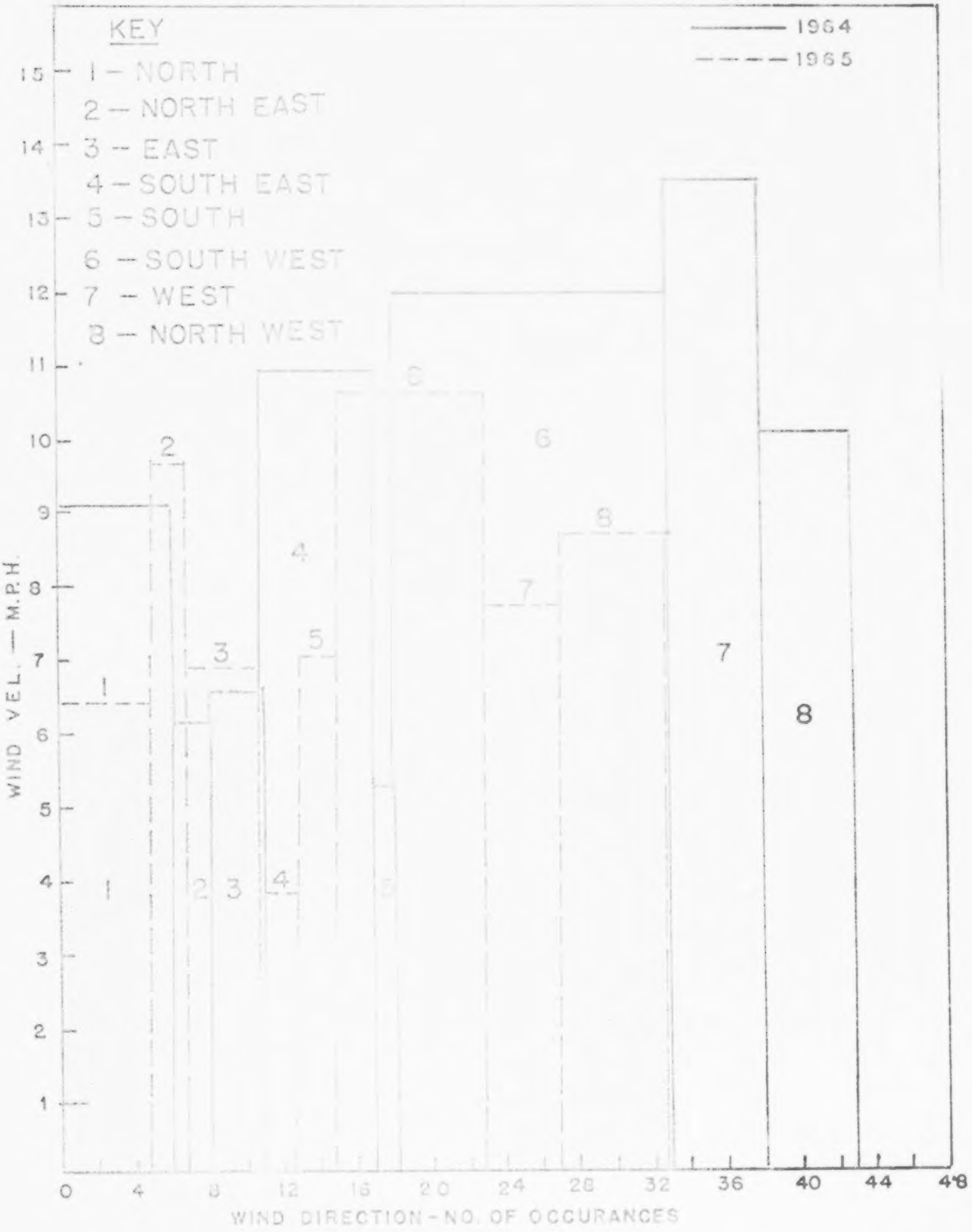


FIG. 28 Average wind velocity and wind direction in basin

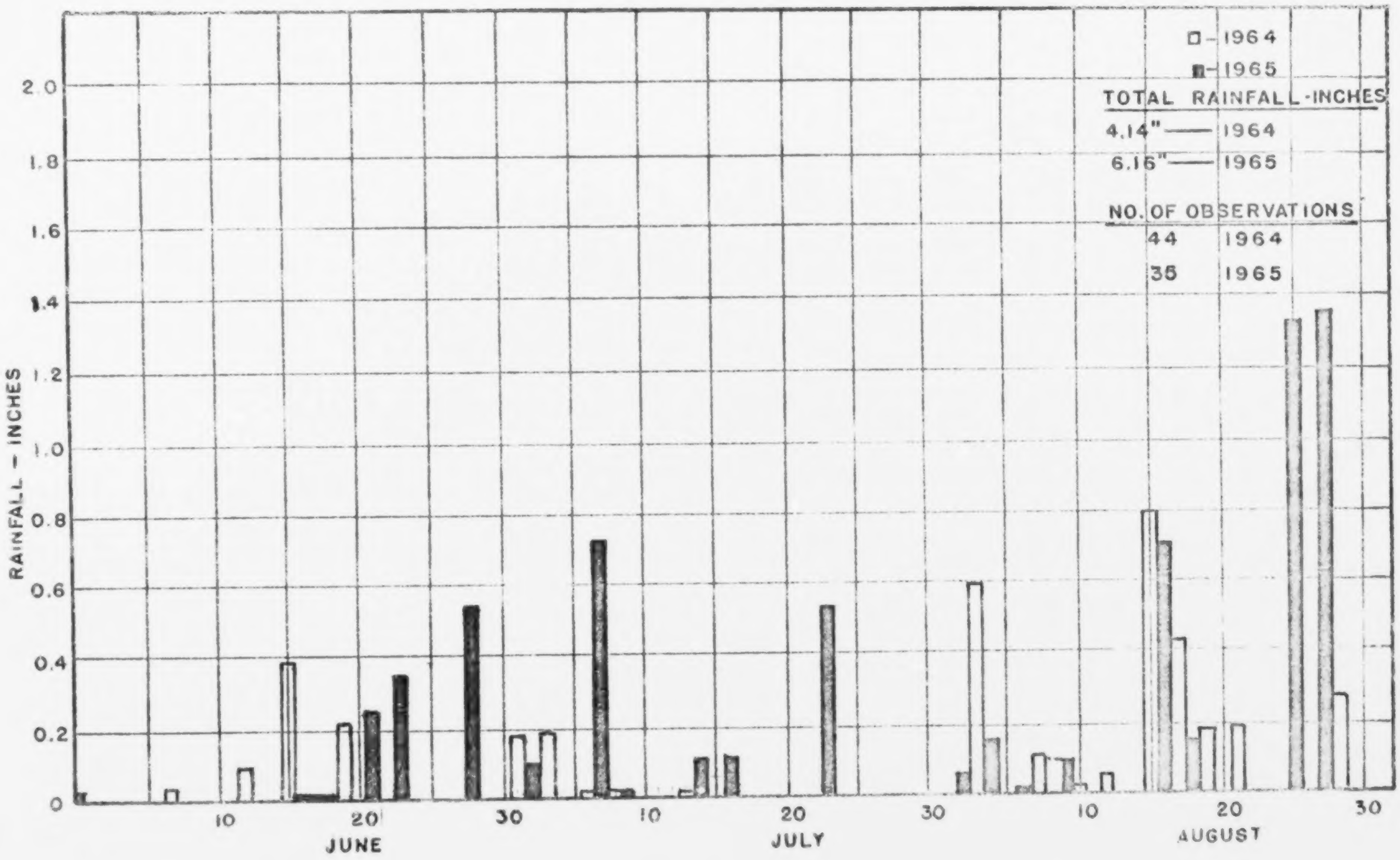


FIG. 29 Total Rainfall for study periods 1964 - 1965

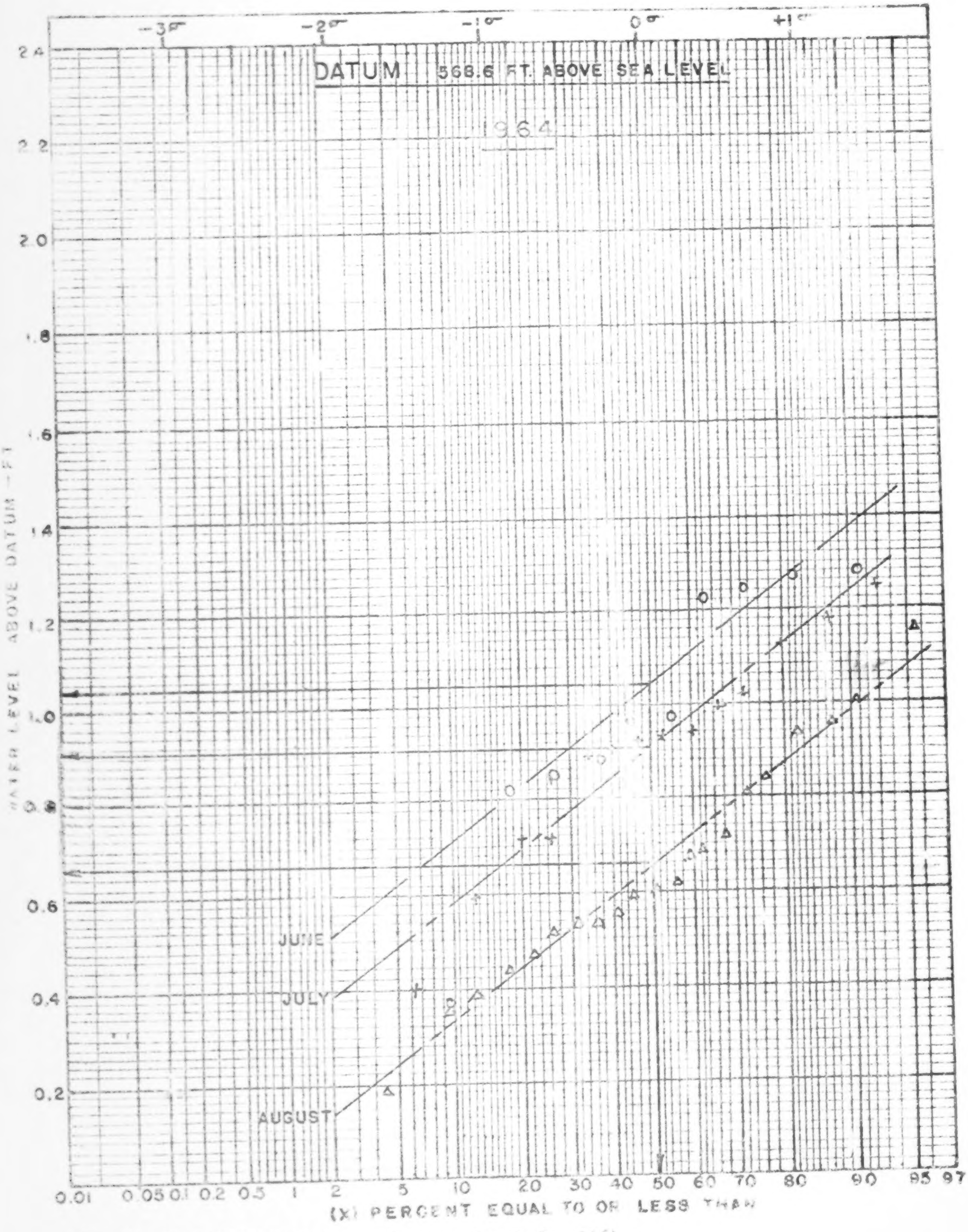


FIG. 30 Probability diagram of water level for 1964

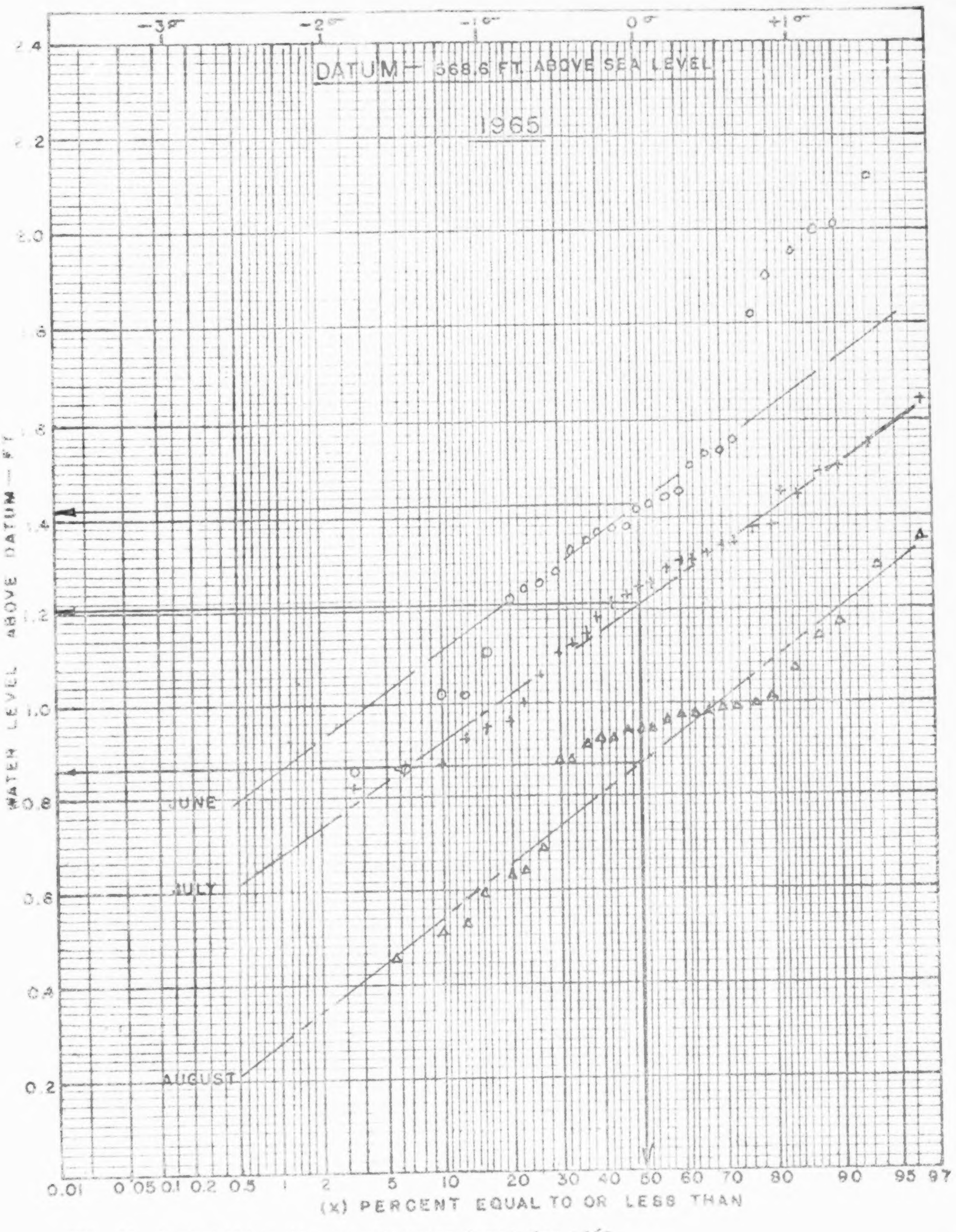


FIG. 31 Probability diagram of water level for 1965

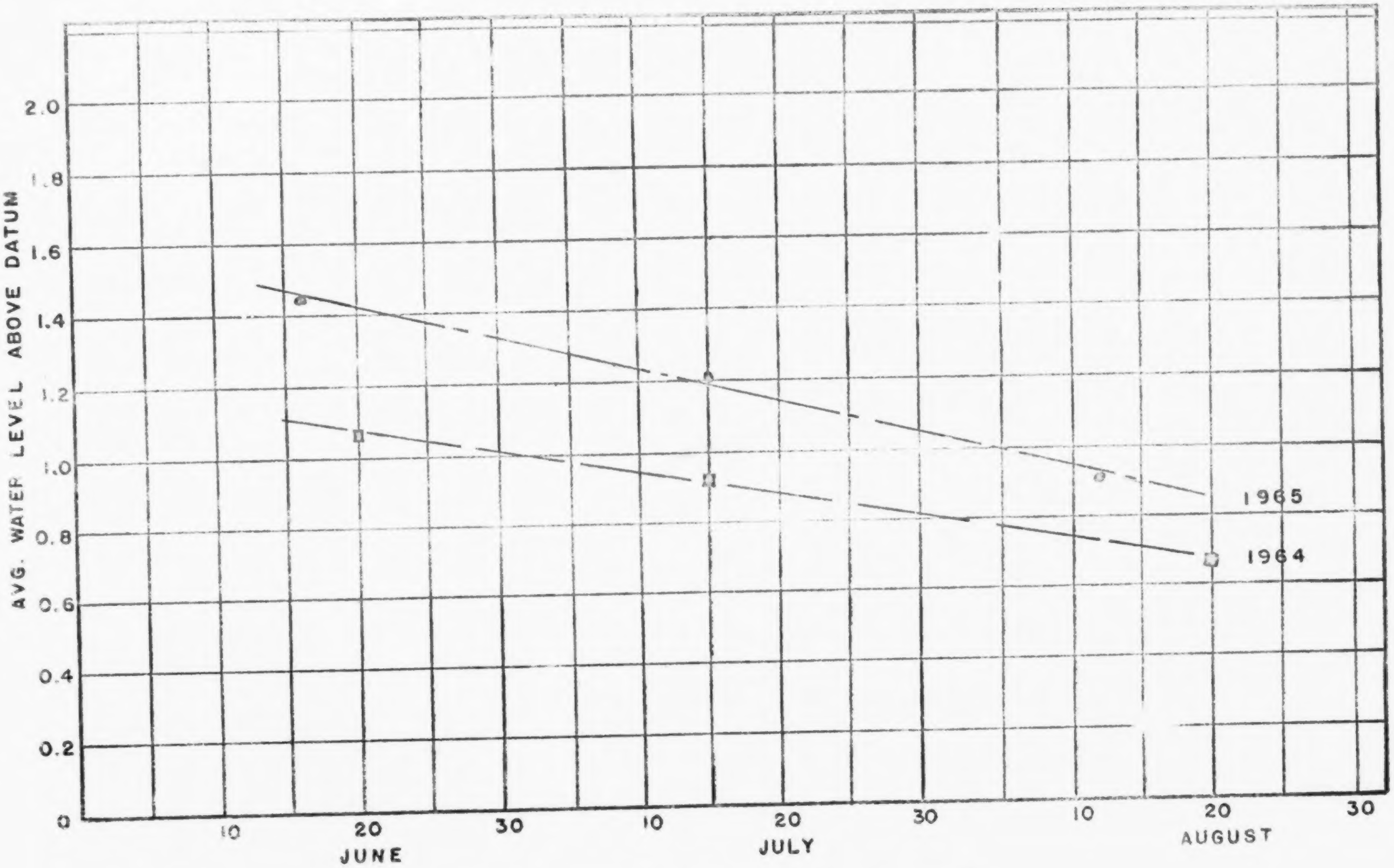


FIG. 32 Average water level above datum (568.6 ft. above sea level)

STATISTICAL ANALYSIS DISCUSSION

There was a wide range of environmental factors in the basin area. Because of this factor, it was decided to use a statistical approach to determine whether the observed trends were valid. The method used was a graphical approach developed by Veltz and Gannon (5). Parameters such as the 50 percentile average, ratio of the 50% average, and the standard deviation were plotted.

Observation of Figures 1-a to 32 reveals that a relationship between the standard environmental factors did indeed exist.

First, it can be seen that aeration was beneficial. Aeration between Stations 1 and 2 show that low pressure aeration does improve the dissolved oxygen content.

It can also be seen that in the aerated portion there was less carbon dioxide, lower phosphate and nitrate content, plus lesser numbers of phytoplankton.

The most probable number of coliform and enterococci organisms were not plotted as the variance shown in the original plots were obviously far different between Stations 1 and 4. It was surprising that the coliform and enterococci densities were far lower in the marina when one considers the usage of the basin as a marina. It was expected at the inception of the study that the opposite would be true.

Although this has been one isolated experiment it is obvious that some form of low pressure aeration would result in a reduction of the national pollution problem.

CONCLUSIONS

Results of the low pressure aeration studies have shown that bubble diffusion increased algal growth rates as long as proper conditions existed, i.e., sufficient nutrients, light intensity, proper temperature, and optimum pH. It was proved that under such conditions increased stripping of nutrients took place.

Due to the vertical flow pattern produced by the bubbles, dissolved oxygen concentration tended to approach saturation levels. This action also eliminated floating masses of algal growth.

Microbiological analysis showed evidence that coliform and enterococci counts were below that of the Maumee River, indicating the aeration system acted as a vehicle for bacteria and phytoplankton to reduce pollutants entering the marina at a higher rate than would have occurred in an unaerated system.

From a practical viewpoint, low pressure aeration would be of value for treating final effluent from waste treatment plants; reducing pollution in small low velocity streams; and for secondary treatment for primary type waste plants for small communities where sufficient land is available for lagoons.

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